THE PRACTICAL

SURVEYOR'S GUIDE.

CONTAINING

THE NECESSARY INFORMATION TO MAKE ANY PERSON OF COMMON CAPACITY A FINISHED LAND SURVEYOR, WITHOUT THE AID OF A TEACHER.

195
140

BY

ANDREW DUNCAN,

Land Surveyor and Civil Engineer.

A NEW, REVISED AND GREATLY ENLARGED EDITION.

ILLUSTRATED BY SEVENTY-TWO ENGRAVINGS.

PHILADELPHIA:

HENRY CAREY BAIRD & CO.,

Industrial Publishers, Booksellers and Importers,

810 WALNUT STREET.

1892.

PRINTED AT
COLLINS PRINTING HOUSE,
PHILADELPHIA, U. S. A.

PREFACE TO THE REVISED EDITION.

As shown by the constant demand for it, "THE PRACTICAL SURVEYOR'S GUIDE" still maintains the popularity and reputation it has, for so many years, enjoyed.

The issue of a new edition having become necessary, a considerable amount of new matter has been added in order to make the work still more useful to the reader. No changes, except necessary corrections, have been made in the original text.

The greater portion of the new matter has been translated from "Katechismus der Feldmesskunst," by Dr. C. Pietsch, a very popular German work which has passed through five editions. In making these additions, the aim of the author of the original work—to prepare a book sufficiently concise and instructive in the several details—has been constantly kept in view.

It is hoped that this new edition may prove of value to surveyors, professional and unprofessional, in giving them the needed information in a clear and simple manner, unburdened with unnecessary matter.

Philadelphia, November 15, 1892.

PREFACE TO THE FIRST EDITION.

THE following compilation is made in consequence of the undersigned not having met with any work on Surveying sufficiently concise, and instructive in the several details, necessary to qualify properly the practical surveyor. Many of the works already published contain subjects not necessary in such treatises; such as Geometry, Plane Trigonometry, &c., which subjects, it is taken for granted, all who intend to become proficients have studied prior to reading Surveying. They are also found not to contain instruction that in recent improvements the surveyor requires to know. Many of these things the compiler of this short treatise, will endeavour to supply; also, many other necessary things, which, in his long experience, he has found indispensable to the correct practitioner. He has collected the most necessary instruction in leveling and profiling, with a new and speedy plan of setting grades on rail and plank roads. The method of inflecting curves, not hitherto sufficiently explained. The description and design of a new instrument whereby distances are found at once without any calculation. A new method of surveying any tract of land by measuring one line through it, with a geometrical demonstration of the same. A geometrical method of correcting surveys taken with the Com-

pass, to fit them for calculation, with a table of corrections for certain distances, but applicable to all. A short method of finding the angles from the courses, and *vice versâ*. The method of surveying with the Compass through any mine or iron works, and to correct the deflections of the needle by attraction. Description of an instrument by the help of which any gentleman may measure a map by inspection, without calculation. A new and short method of calculation, wherein fewer figures are used than in the common method; also, the Pennsylvania method. Tables of difference of Latitude and Departure, made expressly for two pole chains, but which can also be used with four poles. The method of correcting the diurnal variation of the needle, most useful in tracing the boundaries of surveys, a complete description of which is given with the reason for using 57-3° and how it is found. Various methods of plotting and embellishing maps. The most correct method of laying off lots with a pole, plummets, &c. Description of a new Compass which the compiler has contrived for that purpose, and which is made by REID & SONS, Smithfield street, Pittsburgh.

The compiler does not deny that he has borrowed from many authors those things he has found best adapted to the completion of a work adequate to make a finished American Surveyor, of which an unprejudiced and enlightened public are the best judges.

ANDREW DUNCAN,

Land Surveyor and Civil Engineer,

Office, Odeon Building, Fourth St., Pittsburgh.

CONTENTS.

INTRODUCTION.

INSTRUMENTS FOR SETTING-OUT RIGHT ANGLES, AND THEIR USE.

TRIGONOMETRICAL SURVEYING.

TABLES OF SURVEYS.

SYSTEMS OF RECTANGULAR SURVEYING FOR SURVEYING THE PUBLIC LANDS OF THE UNITED STATES.

PRACTICAL SURVEYOR'S GUIDE.

INTRODUCTION.

THE object of surveying consists in taking the measurements and observations of larger or smaller parts of the earth's surface, so that a map may be drawn of the part surveyed, and its content calculated. A survey should include all the natural and artificial features of the ground, for instance, rivers, roads, railroads, fences, buildings, limits of cultivation, boundaries of estates, etc. It is, however, not always necessary to take the measurement of all these objects, it depending mainly on the particular object of the survey, which of them are to be included. Thus, for instance, in surveys for economical purposes, the quality of the soil and its producing capacity have to be taken into consideration, which is not necessary in topographical surveys.

The "points" which are to be determined in surveying are not the mathematical points treated of in geometry, but the corners of houses, fences, stones, etc., which are mere points in comparison with the extensive surfaces and areas which they are the means of determining. Strictly speaking, their centres should be regarded as the points alluded to.

A straight line is *determined*, that is, has its length and its position fixed, when the points at its extremities are determined; and a *plane surface* has its form and dimensions determined, when the lines which bound it are determined. Consequently the determination of the relative position of points is all that is necessary for the principal objects of surveying, which are to make a map of any surface, such as a field, farm, etc.

A map of a survey is a miniature copy of the field, farm, etc., as it would be seen by an eye moving over it; or as it would appear, if, from every point of its irregular surface, plumb lines were dropped to a level surface under it, forming what is called in geometrical language its horizontal projection.

The scale, according to which the map is drawn, varies according to the object of the survey. Thus, for economical surveys it is $\frac{1}{1000}$ to $\frac{1}{5000}$; for city and village surveys about $\frac{1}{500}$; while for topographical surveys it is considerably smaller.

INSTRUMENTS FOR MEASURING DISTANCES, AND THEIR USE.

A POINT in the field may be indicated either by a natural or artificial mark, the vertical corner of a building serving, for instance, for the former. Such corner of a building marks the points at which it intersects the ground. In the same manner a lightning rod or a vertical flag pole may determine a point.

The mode of artificially marking a point in the field depends on the time the mark is to last. If it is to be permanent, as, for instance, the boundaries of estates, stones are used. The intersecting point of two lines cut in the head of the stone indicates the point in the field which is to be marked by the stone. Boundary stones must be set sufficiently deep in the ground to insure the permanency of their position. In taking measurements in cities, cast iron posts, planted perpendicularly in the ground, are frequently used. These posts are provided on the top with a conical aperture for the in-

sertion of a marking pole, so that in measuring the point may be marked even at a greater distance. Temporary artificial marking may be effected by wooden pins. For temporary marking, whilst taking measurements, painted marking poles shod with iron are used. If the distances are not very long, eight-feet poles, and for longer distances, 12-, and even 20- or 25-feet poles may be necessary, which then require rope-stays. The shorter poles are painted in alternate lengths of black and white, or red and white, the longer have the top painted and a red flag attached.

A straight line in the field is established by two points marked in the above-described manner. The determination of further points in the straight line may, however, be effected in various ways and, hence, examples referring to definite cases will here be given.

Let the points A and B, Fig. 1, indicate a straight line marked in the field by two poles. To find the point C lying in the prolongation of the straight line AB.

Proceed with a marking pole to the neighborhood of the point C to be sought, and walk in a direction

perpendicular to AB, until to the eye, looking in

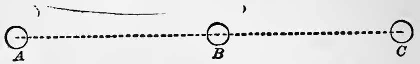


Fig. 1.

the direction of BA, A appears to be covered by the pole B. Then plant the marking pole, which had been taken along, so that it covers the poles A and B. The pole then marks a point C from AB. However, the poles possess a thickness, which must not be neglected, and hence the accurate execution of the operation is not as easy as it may appear from the above description. After planting the pole C, step back a few paces and examine its position.

From Fig. 2 it will be seen that an angular space PoP is hid from the eye at o, by the pole C, this angular space being the greater, the nearer the eye

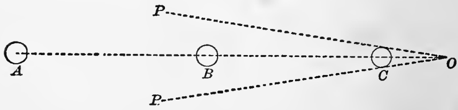


Fig. 2.

is to the pole. To the eye at o, the poles A and B

appear simultaneously covered, as long as they lie in the angular space $P\ o\ P$, even if C is not exactly in the straight line AB. Hence, to reduce this angular space as much as possible, it is recommended to step back at least a few paces, in order to examine whether the poles A, B, C are in a straight line.

If the poles used have the same diameter, the position of the pole C may also be tested by bringing the eye in such a position that now the right, and then the left edges of the poles A and C cover each other. If this is feasible, the pole C stands in the straight line AB; because if C is not in a straight line as shown in Fig. 3, the pole B prevents the right edges of A and C from being covered.

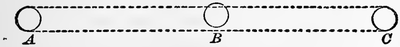


Fig. 3.

The pole C is now said to be ranged in the direction AB, or aligned in the straight line AB.

Two points, A and B, marked by poles, being given, to find a point C of the straight line AB, which lies between A and B.

Place yourself a few steps behind B, so that to the eye the pole A appears to be covered by B. Then by signals direct an assistant to shift the pole C, held in a vertical position, in the direction of AB until it is also covered by B. The pole then marks a point C in the straight line AB. In this case it is also said the pole is ranged or aligned in the straight line AB.

In order to maintain the pole C in a perpendicular position, the assistant should grasp it above the middle, and hold it pendent between the thumb and index finger. The pole then assumes by itself a perpendicular position.

It is, of course, necessary to explain to the assistant the meaning of the signals. He must further be instructed to constantly turn the face towards the surveyor, and hold the pole in a perpendicular position with the arm extended.

As regards signals, the shifting of the pole to the right or left by the assistant is indicated by lifting the right or left arm. Making signs to the right or left for this purpose should be avoided, as they might be readily misunderstood, especially at a greater distance. At great distances, or with an

unfavorable light, it is also advisable to hold a readily visible object, for instance, a pocket handkerchief, in the hand. To indicate to the assistant that the pole held by him is in the right position, move the hand up and down in a vertical direction. The assistant then plants the pole in the indicated place.

The poles should be set truly vertical, and so fixed as to remain so. The loss of time in having to send men long distances to reset poles on windy days may be very great. The vertical position of a pole may be readily tested by a plumb line.

The point C of the straight line AB, which lies between A and B, may also be found without the help of an assistant as follows:

First determine according to the directions given on p. 21, a point D in the prolongation of AB (see

Fig 4.

Fig. 4) and then the point C in the prolongation from BD.

How to determine a point in the straight line AB, when it is impossible to take position in the prolongation of AB.

In fixing an intermediate point in the straight line AB according to the preceding methods, it was supposed that the surveyor could place himself in the prolongation of AB, for instance, behind B, and look towards A. This, however, is sometimes not possible if, for instance, the two points A and B are indicated, as in Fig. 5, by the corners of

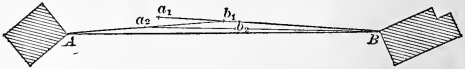


Fig. 5.

two buildings. The mode of procedure is then as follows:

From any desired point a_1, which should be located as near as possible to the straight line AB, place a pole b_1, in the straight line a_1B. Next, from b_1, place a pole, a_2, in the direction of Ab_1. Then again from a_2, place a pole, b_2, in the direction of a_2B, and so on. The poles a_1, b_1, a_2, b_2, constantly come closer to the straight line AB.

After a few repetitions of this operation, a point a or b, lying in the straight line AB, will be reached.

The above described process is also employed for determining an intermediate point, when the straight line AB passes over a hill, so that it is impossible to see B from A. The assistant must, however, be careful to select the points designated in Fig. 5, b_1, b_2, etc., so that A is visible from them, and the points a_1, a_2, a_3, so that B can be seen from them.

Points in the straight line AB may also be determined if a building stands between A and B. Since, however, measurements of distances are required for the purpose, the solution of this problem will be given later on.

Length of a straight line AB. By the length of the straight line AB is understood the length of its horizontal projection, as for instance, the length

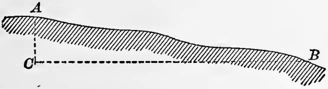


Fig. 6.

CB in Fig. 6. The length AB of the straight line connecting the points A and B, is called the oblique length.

The most important instruments for measuring distances are the *measuring rods*, the *tape-measure* and *the chain.*

The measuring rods, of which at least two are required for measuring a distance, are wooden rods or bars, protected on their ends by metal, and secured against moisture by being several times saturated with hot oil. They are painted aud graduated to feet and tenths, the feet marked on it being, as a rule, alternately painted black and white.

For measuring a horizontal straight line AB, two measuring rods are required. The rod bearer places one end of the first rod at A, and aligns it in the straight line AB. He then takes the second rod, carefully places it against the end of the first and also aligns it in the straight line. He then takes up the first rod and lays it against the end of the second in the direction of AB. The measurement is thus continued until one of the rods extends over the terminal point B of the line to be measured. To guard as much as possible against errors in counting, each rod when taken up should be counted aloud. The distance of the point B from the end of the last rod but one, is then read off

from the graduation of the last rod. Now, suppose the measuring rods are each 20 feet long and the entire distance is 12 measuring rods and $3\frac{1}{2}$ feet, then the length of AB is $(12 \times 20 + 3\frac{1}{2}$ feet) $= 243\frac{1}{2}$ feet.

How to measure with the measuring-rods a line AB, which is not horizontal.

As previously stated, by the length of AB is understood the length of the horizontal projection AB' of AB (Fig. 7). For taking the measurement of this length two persons are required.

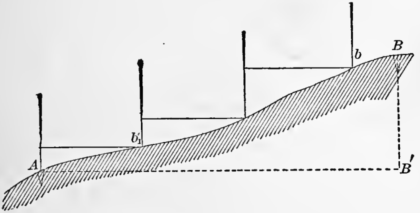


Fig. 7.

One person, by the eye, and for very accurate measurements, with the assistance of the plumb line, sets a prismatic rod perpendicularly at the point A. The other person lays the measuring rod in a truly horizontal position, so that one end

touches the prismatic rod and the other the ground, and aligns it in the straight line AB. The first person then again plants the prismatic rod perpendicularly at b_1, and the second person again lays the measuring rod horizontally on the prismatic rod and aligns it in the direction of AB, and so on. By now counting the number of lengths of measuring rods and measuring the horizontal distance of the terminal point b of the last measuring rod from B, the length of the line AB is found.

The tape-measure and its appurtenances. The steel tape is from 25 to 100 feet or more in length $\frac{1}{2}$ to $\frac{3}{4}$ inch wide, and about $\frac{1}{16}$ inch thick. It is graduated to feet and tenths or twelfths. It is convenient for measurements made at any height from the ground, and also useful for long offsets. But its liability to twist and kink renders it easily broken, while few persons can anywhere be found to repair it. With care one may be safely used for a long time, but it should not be left, even for a moment, in inexperienced hands. Woven tapes strengthend with cords of catgut or wire are also used for the same purpose, but are far less accurate, and are unsuitable for measuring more than

two tape-lengths in one continuous distance, without appreciable error. Common measuring tapes are altogether untrustworthy. They stretch to an extent visible to the naked eye, and shrink after wetting.

On the ends the tape is provided with stout metal rings, which serve for the reception of stakes. The latter are wooden rods 3 to 4 feet long, with a diameter somewhat smaller than that of the terminal rings of the tape. Their lower end is shod with iron, and provided with an iron cross-pin. The object of the pin is a two-fold one: it prevents the ring of the tape from sliding off the stake, and serves for forcing the latter by means of the foot into the ground.

To take measurements with the tape two persons are required, the forward and the hind man, each of them carrying one of the two stakes over which the terminal rings of the tape are pushed. The forward man, walking in the direction of AB, pulls the tape along until the hind man arrives at A. The latter then draws the attention of the forward man to the fact by calling out "halt." The hind man now sets his stake at A, and ranges the

stake of the forward man in the direction of AB. The forward man, after noting the correct position of his stake, pulls the tape tight, so that it covers the point previously marked with the stake. The terminal point of the tape is then marked by the forward man by means of a marking or tally pin. The marking pins of stout steel wire are about 15 inches long, and provided below with a point and above with an eye. At the commencement of measuring the forward man receives ten such marking pins strung through the eyes on a wire ring. After marking the first length of the tape with one of the pins, he calls to the hind man "go on." The tape having become slack by the hind man taking up the stake, is again pulled forward by the forward man until the hind man notifies him, by calling out "halt," that he has arrived at the marking pin. The hind man then takes up the marking pin, replaces it by his stake, adjusts the stake of the forward men, and so on. This process is repeated until the forward man has passed the terminal point B of the line to be measured. The number of marking pins taken up by the hind man then gives the number of tape-lengths. By multiply-

ing the number of marking pins thus taken up with the length (say 100 feet) of the tape, the distance from A to the last marking pin is obtained. To this has to be added the distance from the last marking pin to B, which is read off from the tape itself, in order to obtain the entire length of AB.

If the ten marking pins, with which the forward man sets out when commencing to take the measurement, do not suffice, those collected by the hind man in the course of measuring have to be delivered as often as necessary to the forward man. However, to avoid mistakes, this should be done only after the hind man has taken up the tenth pin. An account of how often the ten marking pins have been delivered to the forward man must, of course, be kept by some convenient arrangement.

Determination of the distance AB when measuring is prevented by an obstacle between A and B.

This problem may be solved in various ways according to special conditions, and hence, a few solutions with reference to definite cases, will here be given.

To find the length AB when the straight line AB passes through a pond or a forest.

Choose a convenient point C (Fig. 8) from which A and B can be seen, and the distances

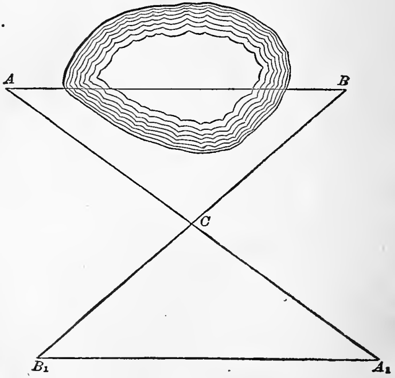


Fig. 8.

measured. Mark the point C by a stake, extend the lines AC and BC beyond C, measure AC and BC, and make

$$A_1C = AC$$
$$B_1C = BC$$

then

$$A_1B_1 = AB$$

Hence it is only necessary to measure A_1B_1.

If, however, A_1B_1 are not accessible, make, in accordance with Fig. 9 or 10,

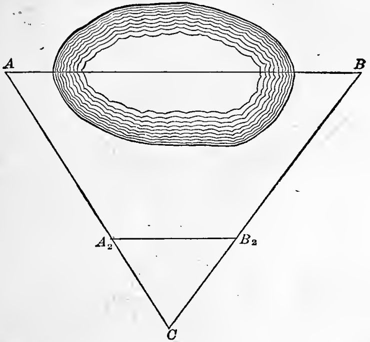


Fig. 9.

$$A_2C = \frac{1}{n} AC$$

$$B_2C = \frac{1}{n} BC$$

then is

$$A_2B_2 = \frac{1}{n} AB$$

and consequently

$$AB = n\, A_2B_2.$$

Hence it is only necessary to measure A_2B_2 and to multiply this line by n.

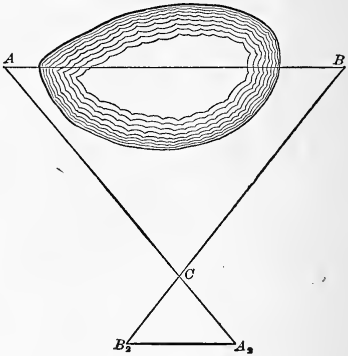


Fig. 10.

How to find the distance AB when the straight line AB continues across a river.

Fix first a point C (Fig. 11) in the extension of AB; choose a convenient point D, from which A, B, C, can be seen, and measurements be taken toward B and C. Measure BD and CD, and make

$$B_1D = \frac{1}{n}BD$$

$$C_1D = \frac{1}{n}CD$$

then is B_1C_1 parallel to BC, or, what is the same, to AB. Now determine the point of intersection A_1 from AD, with the elongation of B_1C_1, by sim-

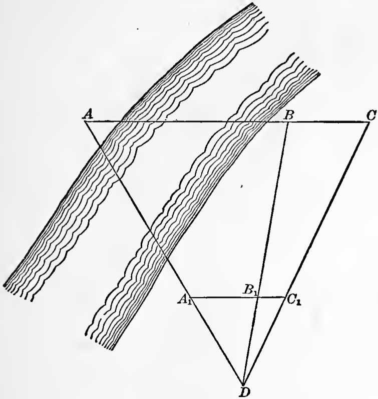


Fig. 11.

ultaneously ranging a stake A_1 in AD and B_1C_1. Then

$$A_1B_1 = \frac{1}{n} AB$$

consequently

$$AB = n. A_1B_1.$$

Hence to find AB it is only necessary to measure A_1B_1, and multiply by n.

Two points A and B are given; between A and B lies a forest. The direction of the straight connecting line of these points is to be determined in A and B.

The direction of AB (Fig. 12) may be established by determining on each side of the forest a

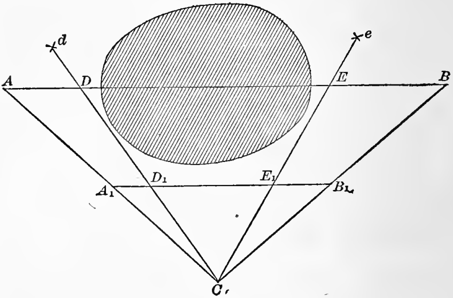


Fig. 12.

point which lies in the straight line AB. If D and E are such points, AD and BE indicate the directions of the straight line AB in the points A and B.

To obtain the points D and E, choose laterally from AB a point C, which allows of looking and

measuring towards A and B. Then measure AC and BC, and make

$$A_1C = \frac{1}{n}AC$$

$$B_1C = \frac{1}{n}BC;$$

then is

$$A_1B_1 = \frac{1}{n}AB.$$

Now, in two points d and e, so situated that they can be seen from C along the edge of the forest, set marking poles, and determine the points of intersection, D_1 and E_1, of the lines Cd and Ce, with A_1B_1. By then making

$$CD = n\ CD_1$$

$$CE = n\ CE_1,$$

D and E are two points of the straight line AB.

Chains. These are made of various patterns, and are galvanized, painted or plain. The latter are most liable to rust, while the first are liable to be less correct from the additional process they undergo. The long-linked pattern, having each link a foot or a Gunter's link in length, is considered advantageous, it being lighter with the same amount of similar material, and its form showing most readily any accidental kink or derangement

during chaining. Furthermore, its links can be readily hammered straight after being accidentally bent. The curb chain and such small-linked patterns are modifications introduced with the use of superior metal, the amount of which is correspondingly reduced. They can be made very light and convenient, but when damaged are less readily rectified than the old pattern. In any case, the length of a new chain should not only be tested with a good standard when simply laid straight, but also again after stretching it by a weight.

During the progress of survey work, the length of the chain should be daily tested by comparison with a temporary standard marked for the purpose and kept invariable. The ordinary *surveyor's chain* is 66 feet, or four poles long, composed of 100 links, each connected to the other by two rings, and furnished with tally-marks at the end of every ten links. The tallies should be read from the beginning to the end of the chain, and not from both ends to the middle.

Grumman's Patent Chains. These chains, invented and patented by J. M. Grumman, of Brooklyn, N. Y., are made of very light steel wire, the

links being finely tempered and so formed at the ends as to fold together readily and thus dispense with the use of rings.

Vara Chains. The Spanish or Mexican *Vara*, which is in general use in Texas, Mexico, Cuba and South America, is $33\frac{1}{3}$ inches long. The chains are made of ten or twenty varas, each vara being usually divided into five links, each link, including a ring at each end, is, therefore $6\frac{2}{3}$ inches. A chain of ten varas has fifty links; of twenty varas one hundred links. Each vara is marked by a round brass tally, numbered from one to nine in the ten-vara chain, and from one to ten, each way, in the twenty-vara chain. Sometimes, but rarely, the vara is divided into four links; a ten-vara chain then has forty links, and a twenty-vara, eighty links.

Metre Chains. The French metre is very generally used as a standard in South America, the West Indies, etc. The number of links to a metre and the tallies are similar to those of the vara.

Marking Pins. In chaining there are needed ten marking pins or chain stakes, made of iron, steel or brass wire, as may be preferred. The

pins are about 14 inches long, pointed at one end, to enter the ground, and formed into a ring at the other, for convenience in handling. They are sometimes loaded with a little mass of lead around the lower end, so as to answer as a plumb when dropped to the ground, from the suspended end of the chain.

In land measurement, the acre is the unit. It contains 4 roods, and a rood contains 40 perches. A perch is a square rod, otherwise called a pole. A rod is $5\frac{1}{2}$ yards or $16\frac{1}{2}$ feet.

Hence, 1 acre $=$ 4 roods $=$ 160 perches $=$ 4,840 square yards $=$ 43,560 square feet.

One square mile $= 5{,}280 \times 5{,}280$ feet $= 640$ acres.

Since the ordinary surveyor's chain is 66 feet long, a square chain contains 4,356 square feet, and, consequently, 10 square chains make one acre. Care should be taken not to confound 10 square chains with 10 chains square. The former make one acre; the latter space contains 10 acres.

When the contents of a piece of land is given in square links, as is customary, cut off four figures on the right (*i. e.*, divide by 10,000); to get it

into square chains and decimal parts of a chain, cut off the right hand figure of the square chains, and the remaining figures will be acres. Multiply the remainder by 4, and the figure, if any, outside of the new decimal point will be roods. Multiply the remainder by 40, and the outside figures will be perches. The nearest round number is usually taken for the perches, fractions less than half a perch being disregarded.

Thus—

86.22 square chains = 8 acres, 2 roods, 20 perches;

Also,

64.1818 " = 6 " 1 " 27 "

Also,

43.7564 " = 4 " 1 " 20 "

Various methods of measuring distances. Wheel-pedometers record on a dial-face the number of revolutions of, or distance passed over, by a wheel rolling on the surface of the ground. On very smooth and even ground the results are moderately fair, the error being chiefly due to slipping.

Pacing and pedometer. Next to guessing,

simple pacing is the worst method of obtaining distance, the inequality of the paces under various conditions, combined with the errors in counting, rendering it very inaccurate. A pedometer may be used to register the number of paces taken without any attention on the part of the person wearing it. It is made in the form of a watch, and carried in the pocket. The number of steps given by the pedometer, multiplied by the length of the step, will give approximately any distance walked over. In another form the instrument is intended to be regulated according to the length of the step of the person carrying it, and then the distance is registered on the dial in miles. The pacing adopted should be even, but natural, and not strained with the mistaken object of conforming to any arbitrary length, for instance, three feet. Some paced distance, on the level, up-hill and down-hill, should be tested by careful measurement to obtain the ratio for reduction to yards, feet or miles, under these three conditions of any future pacings. The ratio should again be frequently checked. It is also necessary to acquire the art of walking in a straight direction. To do this, fix

the eye on two objects in the desired line, such as two trees, bushes, or stones, or tufts of grass. Walk forward, keeping the nearest of these objects steadily covering the other. Before getting up to the nearest object, choose a new one in line further ahead, and then proceed as before, and so on.

Guessing or judging distance may, with continued practice and checking, be carried to an accuracy that is surprising. The main points to be noticed are the rise or fall of the ground and the direction from which the light falls on any object at the distant point. Some persons estimate in yards, others in their own paces, which are more readily available for testing such guesses.

INSTRUMENTS FOR SETTING-OUT RIGHT ANGLES, AND THEIR USE.

The simplest instrument for this purpose is the *surveyor's cross*, or *cross staff*. It consists of a block of hard grained wood, 3 or 4 inches square, and $1\frac{1}{2}$ to 2 inches thick, having two saw-cuts more than half through its thickness, and intersecting each other at right angles at the centre of the block. This block is fixed on a pointed staff, on which it can turn freely.

Another form of the *surveyor's cross* (Fig. 13) consists of two pairs of sights (diopters) placed at the ends of two bars at right angles to each other. The slit, and the opening with a hair stretched from its top to its bottom, are respectively at the top of one sight and at the bottom of the opposite sight. The cross sits by means of a socket upon a pointed staff shod with iron.

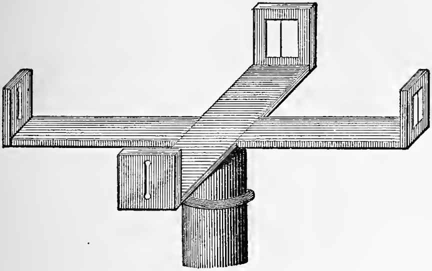


Fig. 13.

Another form of the surveyor's cross, the so-called *cross staff head*, is shown in Fig. 14. It is octagonal in shape. Four sides of the head are provided with sights (diopters), the oculars and objectives of which consist of slits (like A and B), while upon each of the other four sides a slit CC' serves as the ocular, and a hair DD' as the objective, the oculars and objectives upon the parallel sides belonging, of course, together. The visual planes AB, $A'B'$, as well as CD and $C'D'$ stand perpendicularly opposite to one another and intersect in the axis of the head, which is also the axis of the socket H and of the staff stuck in the latter.

With the assistance of either of the above described instruments the following problems may be solved:

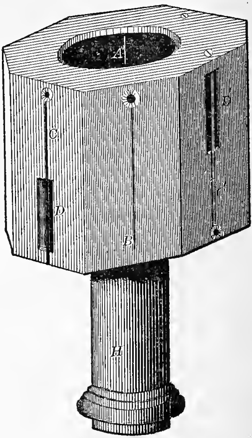


Fig. 14.

1. To erect a perpendicular at the point C in the straight line AB.

2. To let fall a perpendicular to a straight line AB from a point C.

3. A straight line through the points AB is

given. An intermediate point C in the straight line is to be found without entering the prolongation of AB.

How to erect a perpendicular at the point C in the straight line AB.

It is supposed the point C (Fig. 15) has been found by ranging a stake in the direction AB. Set

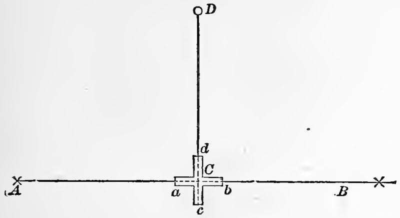


Fig. 15.

the instrument at C, and turn its head until the stake A is seen through the sight ab from b. By now setting a stake D in the visual plane of the other sight ed, then CD is perpendicular upon AB, because the visual planes of the two sights stand perpendicularly one upon the other.

How to let fall a perpendicular to a straight line AB from a point C.

First determine a point E in the prolongation of AB (Fig. 16). Then set up the instrument at a point of the straight line AB, which seems to the eye to be about the bottom of the perpendicular. Now turn the head of the instrument until B is seen through one of the sights, and note whether

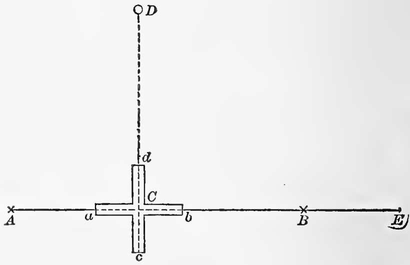


Fig. 16.

the stake C is in the visual plane of the other sight. If such is the case, the staff of the instrument marks the bottom D of the perpendicular CD. However, if C lies to the right or left of the visual plane, move the instrument to the right or left, and repeat the operation until the correct spot is found.

How to determine an intermediate point C in the straight line AB.

Set the instrument in what is supposed to be about the center of AB, and sight through the sight ab the point B. If the point chosen lies in the straight line AB at about C (Fig. 17), A can also be sighted from b, provided the position of the instrument remains unchanged. If, on the other

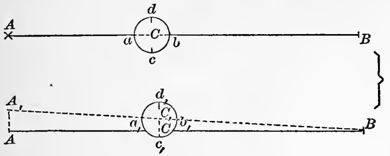


Fig. 17.

hand, the point chosen lies outside the straight line AB at about C_1, then when sighting through ab from a to B, the line of sight from b_1 on, will pass A in the opposite direction, and the distance AA_1, at which it passes A, will be about that of CC_1, when C lies nearly in the centre of AB. Now, therefore, move the instrument about half the distance of AA_1, and repeat the operation until the back-sight covers A.

To test whether the visual planes of the two sights (diopters) stand perpendicularly one upon the other.

Suppose AB (Fig. 18) is a straight line marked by two stakes A and B, and C an intermediate point in AB. Erect a perpendicular CD at the point C. For this purpose sight through the sight ab the stake A, and then set the stake D in the visual plane of the sight cd. The straight line

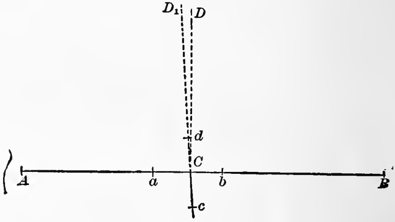


Fig. 18.

CD_1 stands perpendicular upon AB only when the angle of the visual planes of the two sights is a right one. If it is not exactly a right angle, but as in Fig. 18, somewhat smaller, the angle ACD will also to the same extent be smaller than a right angle, because by the operation just described the angle aCd has actually been laid out at the point C in AB.

By now turning the head of the instrument (see

Fig. 19) until the visual plane *ab* covers the stake *D*, and again setting in the visual plane of the other sight a stake *E*, then the angle D_1CE is equal to the angle aCd, and consequently the

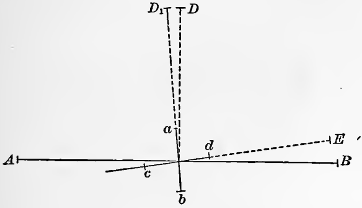


Fig. 19.

angle ACE is double the angle of the visual planes of the two sights. Hence the instrument is correct only when ACE is an obtuse angle, AC and E lie in a straight line, and the plane of sight *cd* covers, in the last position of the instrument, the point *B*.

Surveyor's angle-mirror. This instrument (Fig. 20), consists of two mirrors, S_1 and S_2, so placed as to form an angle of 45°. The mirrors are secured in a brass box closed towards the side of the vertex of the angle formed by them, and open on the other side. Above the mirrors the

sides of the box are provided with rectangular apertures, the so-called windows F_1 and F_2. To the bottom plate G is secured a handle which, as a rule, is provided with a small hook, to which a plumb bob may be suspended.

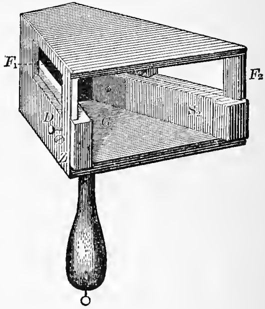


Fig. 20.

The construction of the angle-mirror is based upon the laws of the reflection of light by plane mirrors, which are as follows:

1. The reflected ray lies in the plane determined by the axis of incidence and the incident ray.

2. The angle of reflection is equal to the angle of incidence.

By the *axis of incidence* of a ray of light is understood the perpendicular upon the plane of the mirror at the point at which the ray of light strikes it; and by the *angle of incidence*, the angle which the incident rays form with the axis of incidence. By the *angle of reflection* is understood the angle which the reflected ray of light makes with the angle of incidence.

The mode of operation of the angle-mirror will be explained by the scheme, Fig. 21, in which the two mirrors, S_1 and S_2 are represented as simple lines in ground plan.

Suppose, in the direction AB, a ray of light falls upon the mirror S_1. The axis of incidence for this ray is the perpendicular Bb in the point B upon the mirror S_1. The angle of incidence is the angle ABb. If the ray AB is reflected towards BC, then the angle CBb is the angle of reflection. Now, as previously stated, according to the laws of reflection, the angle of reflection is equal to the angle of incidence, and hence,

$$< CBb = < ABb.$$

The ray BC now falls in the point C upon the

mirror S_2. The axis of incidence here is Cc, and the angle of incidence is BCc. If the ray is reflected from the mirror S_2 towards CD, then the angle DCc is the angle of reflection, and hence

$$<DCc = <BCc.$$

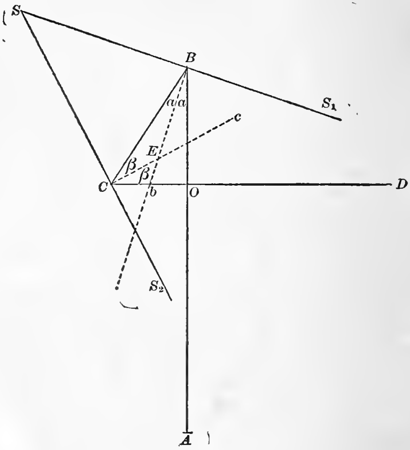


Fig. 21.

Thus, if a ray enters the angle-mirror in the direc tion AB, it passes out in the direction of CD Now, it can be demonstrated that the ray CD pass

ing out stands perpendicularly upon the entering ray AB.

If the point of intersection of the two axes of incidence be designated E, then according to the proposition, "the outward angle of a triangle is equal to the sum of the inward opposite angles,"

$$1. \quad \angle DOB = \angle OBC + \angle OCB$$
$$= 2\alpha + 2\beta$$
$$= 2(\alpha + \beta).$$

$$2. \quad \angle cEB = \angle EBC + \angle ECB$$
$$= \alpha + \beta.$$

From this it follows that

$$\angle DOB = 2 \angle cEB.$$

However, according to the proposition, "two angles whose sides stand perpendicularly upon each other are equal,"

$$\angle CEB = \angle BSC$$
$$= 45°,$$

consequently

$$\angle DOB = 90°.$$

Thus, the angle DOB, which the ray passing out forms with the entering ray, is constant; it is inde-

pendent of the angle of incidence A and of the ray AB. From this it follows that the direction of the ray passing out is not changed by turning the angle mirror around its axis. Therefore, the eye looking in the direction AB into the mirror, will see a quiescent picture, though the mirror may be turned around its axis. This property renders the angle-mirror very suitable for use, it requiring no support, it being simply held in the hand.

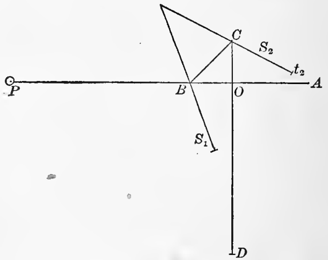


Fig. 22.

Use of the angle-mirror. By holding the angle-mirror before the eye A, Fig. 22, so that both mirrors are vertical, and the eye on looking past the edge t_2 of the mirror S_2 through the window of the mirror S_1, sees a stake P, while at the same

time it looks in the same direction into the mirror S_1, the visual ray, according to the explanation previously given, takes the course $ABCD$. If a stake stands in the straight line CD, the eye A sees this stake in the mirror S_1 at B. Hence the stake D appears to the eye at A exactly in the same direction as P. The stake P, seen directly, forms the straight continuation of the picture of the stake D, which lies sideways. The point O is the vertex of a right angle, whose sides pass through the points B and D. The angle-mirror is of such small dimensions that in the field it may be taken as a point; hence, O may be considered coincident with the point obtained by plumbing the angle-mirror. If, therefore, a point P, seen through the mirror S_1, lies perpendicularly over the picture of another point D seen in the mirror S_1, the directions from the location of the mirror to these two points are perpendicular to one another.

How to erect with the assistance of the angle-mirror a perpendicular to the straight line AB at a point C in the latter.

Place yourself before the point C (Fig. 23) with the face turned towards the side where the

perpendicular is to be erected. Now hold the angle-mirror, with the open end turned towards A (or B), in a truly perpendicular position over C, and look with the eye O for the picture of the stake A in the mirror. When this has been found, set the

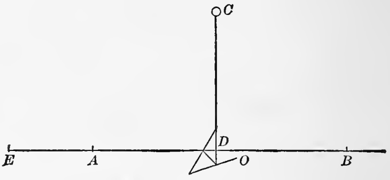


Fig. 23.

stake P, so that when seen through the window of the angle-mirror, it is the direct continuation of A. Then ACD is a right angle and, hence, CD the desired perpendicular.

In order to be convinced at any moment that the angle-mirror is in the straight line AB, it is recommended to previously range in the direction AB, a stake E in the prolongation of AB. The angle-mirror is then in AB, when the pictures of the two stakes A and E cover one another.

How to let fall with the assistance of the angle

mirror a perpendicular CD from a point C to a straight line AB.

Determine first a point E, Fig. 24, in the prolongation of the straight line AB. Then place yourself with the face towards A in the neighborhood of the bottom of the perpendicular sought, so that the eye O is in the straight line AB, which

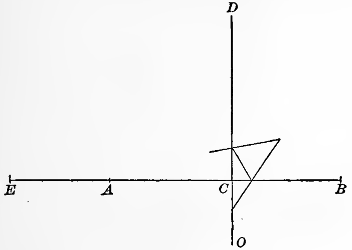


Fig. 24.

is recognized by the two stakes A and E covering one another. Hold the angle-mirror close before the eye, with the opening turned towards C, and note whether the picture of C appearing in the mirror is the straight continuation of the directly seen stake A. If such is the case, the position of the angle-mirror indicates the bottom of the perpen-

dicular; if not, walk back or forward in the straight line until the picture of C is the continuation of A.

How to find with the assistance of the angle-mirror an intermediate point C in the straight line AB.

This operation is based on the following facts, which will be readily understood:

If a perpendicular is first erected at C, Fig. 25,

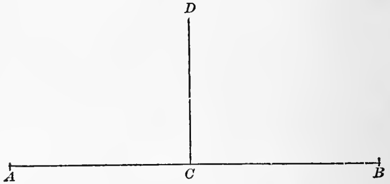


Fig. 25.

upon AC, and then one upon BC, these perpendiculars coincide. If C_1 is not a point in the straight line AB, but has the position indicated in Fig. 26, the two perpendiculars to AC_1 and BC_1 will deviate from each other, the two right angles AC_1D and $BC_1D'_1$ being separated by an angular space, $D_1C_1D'_1$. If now the point C occupies the position indicated by C_2 in Fig. 27, the perpendiculars to

AC_3 and BC_3 also do not cover one another, while the two right angles AC_2D_2 and $BC_2D'_2$ partially cover one another. Hence, it will be seen that

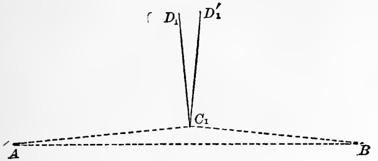


Fig. 26.

the surveyor is at a point C in AB only when the perpendiculars to AC and BC coincide, and fur-

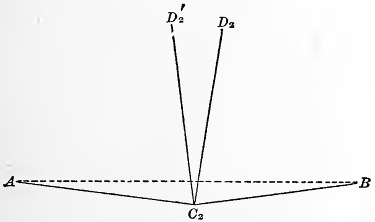


Fig. 27.

ther, that in order to reach the straight line AB, he must walk forward if, as in C_2, the two right angles partially cover one another, or backward

if the two right angles are separated by an angular space.

Testing the angle-mirror as to its accuracy. The two mirrors of the instrument should form an angle of 45°. For the purpose of testing it, range in the given line AB marked by stakes, two stakes C and D, Fig. 28, and laterally plant a stake E in about the centre of CD. Now, with the assistance

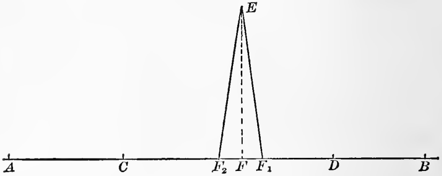


Fig. 28.

of the angle-mirror, let fall a perpendicular to A, according to the directions previously given. This may be effected either by walking in the direction from D to C, until the directly seen stake C is the straight continuation of the picture E seen in the mirror, or by walking in the direction from C to D until the directly seen stake D forms the prolongation of the picture of E. If the mirror is correct,

the operator will both times strike the same point F. If, however, the angle of the two mirrors is not exactly 45°, he will first strike the point F_1 and then the point F_2. Both points F_1 and F_2 will lie at the same distance in opposite directions from the correct point F. (Fig. 28 illustrates a case in which the angle is smaller than 45°.) If, now, F_1 and F_2 have been found, the centre of the distance F_1F_2 is the bottom of the perpendicular sought.

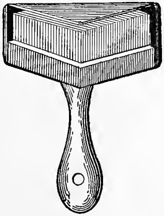


Fig. 29.

Prism for right angles. This instrument (Fig. 29) consists of a glass prism, the cross section of which is a right-angled isosceles triangle. The plane of the hypothenuse of the prism has a smooth reflecting surface. The instrument is pro-

vided with a handle, on the lower end of which is, as a rule, a hook or eye for suspending a plumb-bob. The prism serves as a substitute for the angle-mirror, and, generally speaking, is used in the same manner. It is smaller, so that it can be con-

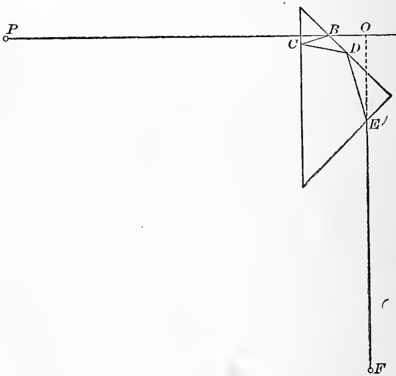


Fig. 30.

veniently carried in the pocket, and, being invariable, does not require to be constantly tested.

Use of the prism. By looking towards the stake P (Fig. 30), and holding the prism before the eye A, so that the axis of the prism stands

vertical, and the visual ray AB strikes the prism in the neighborhood of the sharp edge, and the plane of the hypothenuse stands about perpendicularly upon the visual ray, the latter in passing through the prism takes the course $ABCDEF$. Hence, a stake standing at F would appear to the eye A, looking through the prism, in the direction AP. Thus, while the eye looking over the frame of the prism sees the stake P, it perceives, in the straight continuation of the latter, the picture of the stake F in the prism. The angle POF is a right angle, and its vertex always lies so close to the prism, that in the field, the point obtained by plumbing the prism, may be designated O. Hence, it may be said that the field-point obtained by plumbing the prism is the vertex of a right angle, the sides of which pass through P and through F. If therefore, the stake P, which is directly seen, forms the straight continuation of the picture of the stake F, seen in the prism, then the visual rays from the position of the prism towards P and F stand perpendicularly one upon the other.

To set out right angles with the tape measure alone. There are various methods for setting out

right angles with the tape measure alone; two of them will here be given.

Let AB be the straight line upon which at the point C a perpendicular is to be erected.

1. Measure off equal distances *CD* and *CE* (Fig. 31) on each side of the point *C*. Then after fastening the ends of the tape with two pins at *D* and *E*, grasp the tape in the centre, and walk sideways until both halves of the tape are stretched tight.

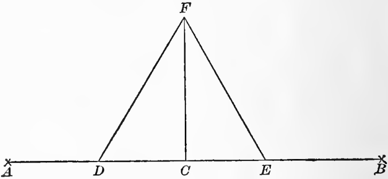


Fig. 31.

The centre *F* of the tape then indicates a point of the perpendicular to be erected in *C*; because the triangle *DFE* is an isosceles triangle, and in such a triangle the line connecting the summit with the centre of the base stands perpendicularly upon the latter.

2. Measure off from *C* (Fig. 32), along the given

line a distance $CD = 6$ metres, then let two assistants hold in CD the ends of a portion of the tape, 18 metres long, grasp the tape at a point E

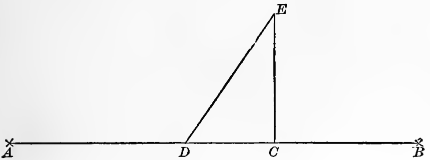


Fig. 32.

at a distance of 8 metres from C and 10 metres from D, and draw it tight. CE is then perpendicular to AB, because the triangle DCE is right-angled at E, since

$$\overline{DE}^2 = 10^2 = 100.$$

and

$$\overline{CD}^2 + \overline{CE}^2 = 6^2 + 8^2 = 36 + 64 = 100,$$

consequently

$$\overline{DE}^2 = \overline{CD}^2 + \overline{CE}^2.$$

In the following a few examples of the application of setting out right angles are given.

1. *Given, two points A and B, which are separated by an obstacle which cannot be seen through,*

for instance, a forest. To determine their connecting line in the points A and B, as well as the length of AB.

Set out through the point A (Fig. 33) any convenient straight line, which passes close by the forest, and determine upon it the bottom C of the

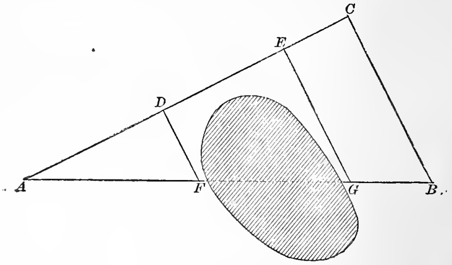


Fig 33.

perpendicular let fall to it from the point B. By now measuring AC and BC, the length is obtained according to the Pythagorean proposition

$$AB = \sqrt{AC^2 + BC^2}$$

To determine the direction of the straight line AB, erect upon AC two perpendiculars which cut the straight line AB outside the forest. Now if

D and E are the bottoms of these perpendiculars and F and G their still unknown points of intersection with AB, it follows from the similarity of the triangles ADF and ACB that

$$FD : BC = AD : AC.$$

Consequently

$$FD = \frac{BC}{AC} AD.$$

From the similarity of the two triangles AEG and ACB, it further follows that

$$GE : BC = AE : AC,$$

and therefore

$$GE = \frac{BC}{AC} AE.$$

By now measuring AD and AE, FD and GE can be calculated with the assistance of the two formulas. By now transferring the lengths thus calculated to the perpendiculars erected in D and E, the points F and G lying in AB are obtained. By AF the direction of the straight line at A is determined by BG at B, and the problem solved.

2. *Given, a straight line AB passing across a lake; its length is to be determined.*

Erect in convenient points C and F (Fig. 34) of the straight line AB perpendiculars and lay out upon them convenient, but equal lengths, CD and FE. The connecting line DE of the terminal points of these lengths is then parallel to AB, and in length equal to CF; consequently

$$AB = AC + DE + FB.$$

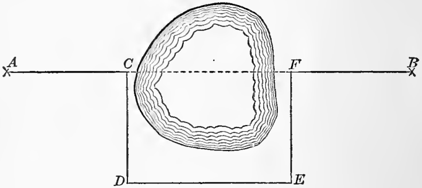


Fig. 34.

Hence it is only necessary to measure the three lengths AC, DE, FB; their sum total gives the length AB.

3. *A given straight line AB strikes in its prolongation an obstacle, which cannot be seen through, for instance, a house; to find the prolongation on the other side of this obstacle.*

Erect upon AB (Fig. 35) at B, a perpendicular BC of such length that the line through C parallel

to AB passes the obstacle. Then erect at B upon DC a perpendicular CD of such length that a per-

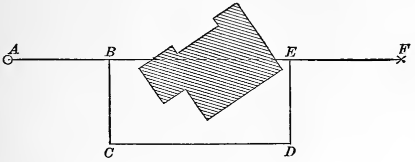


Fig. 35.

pendicular erected at D upon CD passes the obstacle. Make the latter perpendicular DE equal BC; then E is a point in the straight line AB, and the perpendicular EF erected at E upon DE, the prolongation of AB sought.

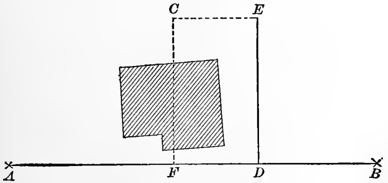


Fig. 36.

4. *A straight line AB is given. From a point C, a perpendicular is to be let fall to the straight*

line, the direct execution of the operation being, however, rendered impossible by an intervening building.

Erect at a convenient point D in AB (Fig. 36) a perpendicular upon AB, and let fall to this perpendicular from C the perpendicular CE. Now measure the distances CE and DE and make

$$DF = CE.$$

Then F is the bottom of the perpendicular sought, and DE its length.

The problem may also be solved as follows:

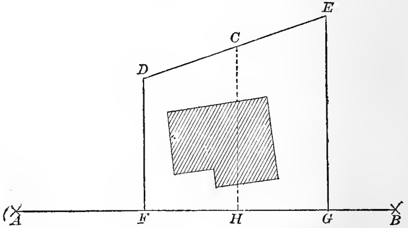


Fig. 37.

Set out through C (Fig. 37) any convenient straight line and measure off upon it from C equal lengths CD and CE. From the points D and E

let fall perpendiculars to the straight line AB. Suppose the bottoms of these perpendiculars are F and G; then the centre H of the length FG is the bottom of the perpendicular sought, and the length of the perpendicular is

$$CH = \frac{1}{2}(DF + EG).$$

To prevent inaccuracies, the erection of one perpendicular upon another must in this method be avoided.

SURVEY OF SMALLER TRACTS WITH THE ASSISTANCE OF THE PREVIOUSLY DESCRIBED INSTRUMENTS.

To survey a three-sided field.

A triangle being determined by the length of its sides, it is only necessary to measure the latter.

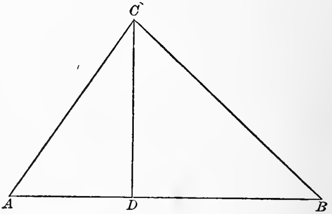


Fig. 38.

A triangle may also be determined by its base AB (Fig. 38), its altitude CD, and the bottom D of its altitude. Hence a three-sided field may be surveyed by determining with the assistance of the

angle-mirror or the prism the bottom D of the perpendicular let fall from C to AB, and then measuring with the chain, tape or rods, the lengths AD, AB and CD.

To survey a many-sided field or polygon. Divide the polygon (Fig. 39) by diagonals into triangles, and measure the three sides of each triangle. Since each triangle is determined by its sides, the polygon also is thereby determined.

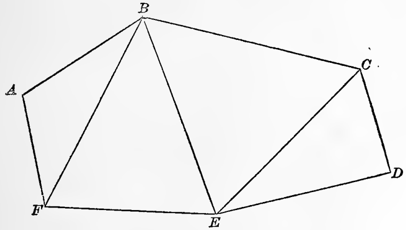


Fig. 39.

Another mode of surveying a polygon is as follows:

Mark out by several stakes a straight line ab (Fig. 40), the so-called base-line and axis of the abscissa, which cuts the polygon as nearly as possible in the direction of its greatest dimension, and

let fall to it perpendiculars from all angles of the polygon. A convenient angle of the polygon, for instance the point C, is then determined, according to its position, by the length of the perpendicular CC_1 let fall from it to the base-line ab, and by the distance of the bottom C_1 of the perpendicular from

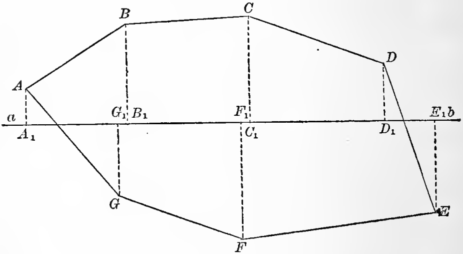


Fig. 40.

a convenient point, for instance A_1, upon the base-line ab, which has been chosen as the initial point for taking the measurement. The distance A_1C_1 is called the abscissa of the point C, and the length CC_1, the ordinate of point C. Hence, every angle of the polygon is determined by its abscissa and ordinate. The abscissa and ordinate taken together are called the coördinates of the point C. This

method of surveying is also called the coördinate or normal method.

Noting the results of the measurements. To note the results of the measurements, so that there cannot be any doubt about their meaning, make first a rough sketch of the tract to be surveyed, and in this sketch, mark the measurements found. The marking must be done according to a definite princi-

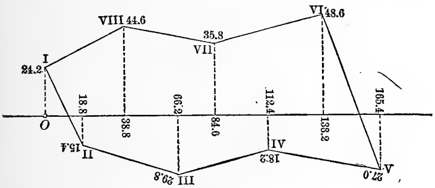


Fig. 41.

ple, so that the position of the figures at once shows to which distances they refer. Write all measurements on the terminal points of the distances vertically to the distance to which they refer, so that, when looked at from the initial point of the distance, they stand upright, *i. e.*, can be read (see Fig. 41). The abscissas are measureed by adhering throughout to the same initial point, in Fig. 38,

they being, for instance, all counted from the point O. The abscissa of the point VII. is 84.6 metres, *i. e.*, the bottom of the perpendicular from the point VII. to the base line is at a distance of 84.6 metres from O; the ordinate of the point VII. is 35.8 metres, *i. e.*, the length of the perpendicular from the point VII. to the basis is 35.8 metres.

Athough the polygon is completely determined by its corner points, it is also advisable to measure the sides. These measurements are written in the sketch either perpendicularly to the sides, in the centre, or on the end of the sides, or parallel to the sides in the centre of the latter.

PROBLEMS.

Problem First.

To reduce two pole chains and links to four pole ones.

If the number of chains be even, the half of them will be four pole ones, to which annex the given links. Thus:

1. In 16 chains, 37 links of two pole chains how many four pole ones:

$$\begin{array}{r} 2)16.\ 37 \\ \hline \textit{Ans.}\quad 8.37 \end{array}$$

But if the number of chains be odd, take half of them and add 50 to the links. Thus:

$$\begin{array}{r} 2)131.40 \\ \hline \textit{Ans.}\quad 65.90 \end{array}$$

Problem Second.

To reduce four pole chains and links to two pole ones. Double the chains and annex the links if

they be less than 50, but if they exceed 50, add one to double the chains and take 50 from the links. Thus: $\overset{\text{C.}}{16}.\overset{\text{L.}}{25}$ of four poles, how many two pole chains.

$$
\begin{array}{rr}
 & 16.25 \\
 & 2 \\
\hline
\textit{Ans.} & 32.25
\end{array}
$$

2d. In $\overset{\text{C.}}{19}.\overset{\text{L.}}{87}$ four pole chains how many two pole ones.

$$
\begin{array}{rr}
 & 19.87 \\
 & 2.50 \\
\hline
\textit{Ans.} & 39.37
\end{array}
$$

To reduce two pole chains and links to perches and decimal of a perch, multiply the chains by two and the links by four, thus: In $\overset{\text{C.}}{16}.\overset{\text{L.}}{37}$ how many perches.

$$
\begin{array}{rr}
 & 16.37 \\
 & 2.\ \ 4 \\
\hline
\textit{Ans.} & 33.48
\end{array}
$$

Article First—of Areas.

A square is a plane figure having four equal sides and four right angles. To find the content,

multiply the side into itself and the product is the content.

EXAMPLE.

Required the area of the square A B C D, one of whose sides is 25 chains 95 links.

```
      25.95
      25.95
     ------
      12975
     23355
    12975
    5190
    -------
A.  67.34025
           4
    --------
R.   1.36100
          40
    --------
P.  14,44000
```

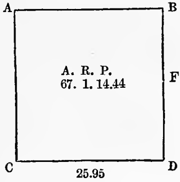


Fig. 42.

A parallelogram is a four sided figure whose opposite sides and angles are equal. To find the area multiply one of the sides by the perpendicular demitted from one of its opposite angles.

EXAMPLE.

Required the area of the parallelogram A B

C D, the length of which is 15 chains, and height $\overset{C.}{12}\ \overset{L.}{64}$.

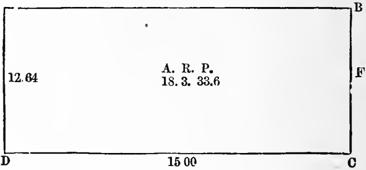


Fig. 43.

```
          12.64
             15
         ------
           6320
          1264
         ------
Acres,   18,960
              4
         ------
Roods,    3.840
              40
          ------
Perches, 33,600
```

The content of an oblong piece of ground and one side are frequently given to find the other. Divide the area in perches by the given side, gives the side required which is easily reduced into chains and links.

If a lot contains 507 perches and is $\overset{C.}{14}.\overset{L.}{25}$ long, what is its width.

```
29)507          2)  4)
   29            17.4827
   ——            ———————       C.  L.
   217.0000      8.25+12.06=8  37.06
   203
   ———
    140
    116
    ———
     240
     232
     ———
       80
       58
       ———
        220
        203
```

To draw maps of these figures is too obvious to require any explanation.

5th. When the sides of the above figures are given in feet and inches, reduce the inches to decimal of a foot. Then multiply the length by the breadth and divide the product by 43560, the number of feet in an acre, the quotient will be the acres and decimal of an acre, which may be reduced to roods and perches by multiplying by 4 for the roods and 40 for the perches, pointing off the proper number of decimal places each time, thus:

A lot of land is 600 feet 4 inches long and 240

feet 3 inches wide, how many acres does it contain.

600.333.×240.25=144230.00325

Acres. A. R. P.
This divided by 43560. gives 3.31106 or 3 1 09.76
4
1.24424
40
9.76960 *Ans.*

6th. A trapezium is a four sided figure the opposite sides of which are neither equal nor parallel. To find the content, measure a diagonal and two perpendiculars to the opposite corners, multiply the diagonal by half the sum of the perpendiculars, and the product will be the area.

EXAMPLE.

Let A B C D be any trapezium, having A C 80 perches, and the perpendiculars as in the figure.

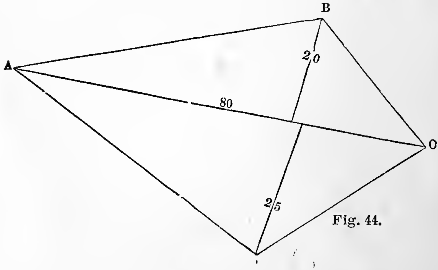


Fig. 44.

```
        25
        20
        ——
      2)45
        ——
      22.5
        80
      ————  A. R. P.
160)1800,0(11.1.00   Ans.
    160
    ———
    200
    160
    ——— R.
  40)40(1
     40
    ———
```

7th. A triangle is a figure having three sides and three angles, any side may be called the base, having the base and perpendicular given. Multiply the base by half the perpendicular, or the base by the whole of the perpendicular, and take half the sum.

EXAMPLE.

Let A B C be any triangle whose base is 100 two pole ch's and 15 links, and perpendicular 40

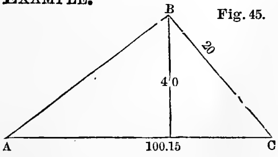


Fig. 45.

chains and 20 links, required the content in acres.

```
                   100  15
                     2   4
                   -------
   40  20          200.6  perches and decimal.
    2   4           40.4  half the perpendicular.
   ------          -----
 2)80   8           8024
   ------          8024
   40   4          -----     A.  R.  P.
             160)8104.24(50  2  24.24   Ans.
                 800
                 ---
              40)104
                  80
                 ---
                  24
```

8th. Having the three sides given to find the area rule, add the three sides together and take half the sum, from which subtract each side severally, multiply the half sum and three remainders continually into each other, and the square root of the product will be the area.

The most satisfactory proof of the above rule is the following:

Let A B C be any triangle, B C its base, A B the greatest side, and A C the least, and let P be half

the perimeter. In A B take A D=A C, join D C and draw A E perpendicular to D C and E G parallel to B C cutting A B in G, with the centre G and radius G E describe a circle cutting A B in L and A B and E G produced in K and H. Join H B and produce A E, H B till they meet in M.

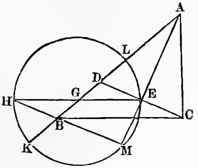


Fig. 46.

Since A D=A C and the angles at E are right, the squares of A E, E D are equal 2 A E,+2 E C and ∴ E D=E C or D C=2 D E. Hence by similar triangles D G E, D B C, B C=2 G E=E H, and B C is also parallel to E H ∴ H B M is parallel to C E D and (Euc. 1st 29th) the angle B M E=D E A, viz: a right angle, and H E being a diameter, M is a point in the circle. But from similar triangles D G E, D B C, D B=2 D G, to each of these equals add A D+A C=2 A D, and B A+A C=2 A G, to each of which equals add B C=2 G E=2 G K ∴ A B+A C+B C=2 A K or A K is =P, half the perimeter. Now the area of the triangle A B C=area A D C+area B D C=A E×D E+

M E×D E (B M being parallel to D C)=A M×D E But by similar triangles A D E, A M B : A E : E D :: A M to M B, and by equi-multiples the first multiplied by third : the second multiplied by the third :: the second × by the third : the second × by the fourth. Hence, A E×A M : E D×A M :: E D×A M : E D×M B, i. e. the area of the triangle is a mean proportional between A E×A M, and E D×M B. Now E D×M B,= P—A B×P—A C, and A E×A M=A L×A K= P×P—B C. Hence the area of the triangle is: $\sqrt{P \times P—A\,B \times P—A\,C \times P—B\,C}$, which is the rule.

EXAMPLE.

9th. Suppose the sides to be measured by a four pole chain and be

	C. L.	
A B	10. 64	
A C	12. 28	
B C	9. 00	
Sum	31. 92	
½ sum	15. 96	
	5. 32	first remainder.
	3. 68	second do.
	6. 96	third do.

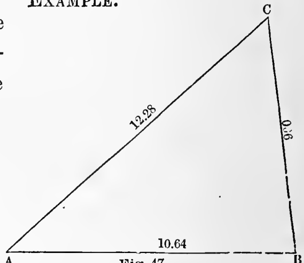


Fig. 47.

```
15.96×5.32×3.68×6.96=2174.71013216(46.6337
                     16
                     ---
                   86)574
                      516
                      ----
                  926)5871
                      5556
                      -----
                 9323)31501
                      27969
                      ------
                93263)353232
                      279789
                      -------
               932667)7344316
                      6528669
```

And since 10 square 4 pole ch's make one acre, this becomes

```
ACRES.
4.66337
      4
-------
2.65348
     40
-------
26.13920
```

The content is 4 A. 2 R. 26 P.

If the sides are in perches and decimal, divide the square root of the products of the half sum and three remainders by 160, and the quotient will be the acres, and the remainder divided by 40 will be the roods.

The same may be more readily done by logarithms, for as the addition of logarithms serves for

the multiplication of their corresponding numbers, and that the number answering to the half of a logarithm will give the square root of the number of that logarithm, it follows that half the sum of the logarithms of half the sum of the sides, and the three remainders will give the area, thus :

Half sum,	15.96	log.	1.20303
First remainder,	5.32	"	0.72591
Second "	3.68	"	0.56585
Third "	6.96	"	0.84261
			2)3.33740
Square four poles	46.63		1.66870

Or, 4.663
4

2.652
40

26.080 — A. R. P. 4 2 26 as before.

10th. When the three sides are given and the angles are required, call either side on which the perpendicular will fall from the opposite angle the base, then as the base is to the sum of the other two sides so is the difference of those sides to the difference of the segments made by the perpendicular, then half that difference added to half the

sum gives the greater, and substracted the less, by which means it is divided into two right angled triangles, the hypothenuse and one leg of each being given, the angles are easily found by plane trigonometry.

EXAMPLE.

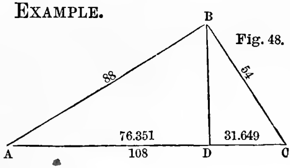


Fig. 48.

Let A B C be any triangle having the sides given as follows, viz: A B 88, B C 54 and A C 108 to find the angles.

```
A B=88   Then as 108 : 142 :: 34
B C=54                   34
  ———                    ———
  142 sum               568
   34 difference.      426
                       ——— —
              108)4828.000(44.703 diff. of the
                   432  segments at the base
                  ———   22.351 half diff.
                   508
                   432
                   ———
                    760
                    756
                    ———
                     400
                     324
```

Then half the base 54+22.351=76.351, the greater segment A D, and 54—22.351=31.649 the less segment.

The triangle is now divided into two right angled triangles, the hypothenuse and base in each being given to find the angles, as follows:

As A B	88	1.9444827
: Rad.	90°	10.0000000
:: A D	76.351	1.8828147
		11.8828147
		1.9444827
: Sine A B D	60°.11′	9.9383320

And 90—60°.11′=29°.49′=Angle B A D. In the same way C B D is found to be 35°.53′ its complement 54°.07′= ∠ B C D.

Now	A B D=	60°.11′
	C B D=	35 .53
Angle	A B C=	96 .04
∠	A=	29 .49
∠	C=	54 .07
		180 .00

180 .00 Proof as the three angles of every plane triangle are equal to 180° per 32d of the 1st of Euclid.

11th. Many things occur to the practical sur-

veyor in the triangle, some of which I shall take notice of in this place. It often happens in practice that the two sides and their included angle are given to find the other angles and side.

Rule.—As the sum of the sides is to their difference so is the tangent of half the sum of the opposite angles to the tangent of half the difference; this half difference added to half the sum of the angles at the base gives the greater, and subtracted the less. Then as sine of either of the base angles is to its opposite side, so is sine of the contained angle to the required side.

Example.

Let A C =80, B C =110, and ∠ A C B 102°.30′ to find A B and the angles A and B.

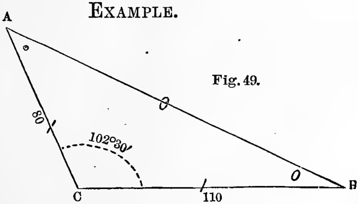


Fig. 49.

Side	B C 110	From	180
Side	A C 80	take ∠ C=	102.30
Sum	190		2)77.30 sum of base angles.
Diff. of sides	30	½ sum =	38.45

Then as	190	log.	2.2787536	38°.45′
:	30	"	1.4771213	7 .13
:: Tag't	38°.45′		9.9044910	
				45 .58 ∠ A
			11.3816123	
			2.2787536	31 .32 ∠ B
:: Tag't of ½ diff.	7°.13′		9.1028587	

Then as sine B	31°.32′	9.7184971
: A C	80	1.9030900
:: sine C	102.30	9.9895815
Or its supplem't	77.30	
		11.8926715
		9.7184971
To A B	149.34	2.1741744

12th. Again, it often happens that the area must be found from the foregoing data, in that case multiply the two sides together, and that product by the natural sine of ½ the contained angle, gives the area.

EXAMPLE.

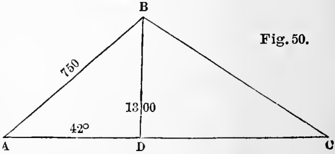


Fig. 50.

Let A B C be a triangle having the side A C 13 chains, A B 7c. 50l. and ∠ B A C 42° to find the area.

7.5
 13

225
75

97.5×.334565 half the nat'l sine of 42°=

32.62 square four pole chains = 3 A. 2 R. 19.2 P. *Ans.*

DEMONSTRATION.

Let fall the perpendicular B. D.

$A\,B : B\,D :: \text{rad} : \text{sine } A$

$\therefore B\,D = \frac{A\,B \times \text{sine } A}{\text{Rad}}$ But rad.=1.

$\therefore$ B D=A B=sine. Multiply each side by A C and B D. A C=A B. Sine A.×A C

But $\frac{A.\,C.\,B\,D}{2}$—the area. Hence,

$\frac{A\,B.\,A\,C.\,\text{Sine } A}{2}$=area, which is the rule.

13th. Let B A C be a triangular farm, and P a well of water. It is required to draw a line or fence from the well that will divide the farm equally between two partners:

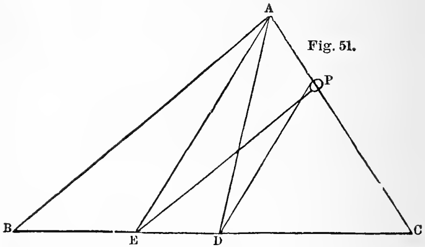


Fig. 51.

Find D the middle of the base, B C, and from P take a course of P D. Again set your instrument at A, and take the same course A E ; cause a pole to be set at E, a line or fence from E to P will bisect the farm, which is easily demonstrated from the figure. See Bland.

14th. Again, suppose the well P, to be situated within the farm, and it be required to divide it equally between three occupants, so that each may have the use of the well.

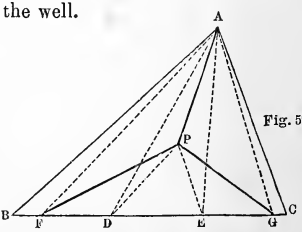


Fig. 52.

In fig. 52 divide the base B C, into three equal parts in D and E. Set your instrument at P, and take

the courses P D and P E. Remove your instrument to A, and take A F the same course as P D, and A G the same as P E. Cause stakes to be driven at F and E in a straight line between B and C. Fences from F, G, and A, to P, trisect the farm, which is plain from the figure.

15th. To find the area of a Trapezoid Rule, multiply half the sum of the parallel sides by the perpendicular distance between them, and the product is the area.

Let figure 53 be a Trapezoid; if A D be bisected in E, and E F drawn parallel to A B or C D, it also bisects B C in F.—Through F draw G H parallel to A D.

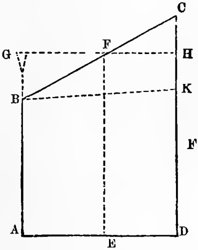
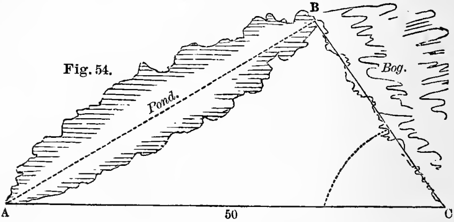


Fig. 53.

It is evident the triangles, B F G, and F C H, are similar and equal. (26th Euclid, 1st.) ∴ E F, half the sum of the sides, multiplied by the perpendicular distance between them, A D, gives the area.

Being surveying on the side of a bog, and wanting four acres to make up a division, and seeing A

Fig. 54.



B would pass through a pond, I found A C fifty chains, and ∠ C 56°; how far must I measure from C towards B, so that the triangle A B C, may contain four acres.

Since A C × C B × ½ the natl. sine of 56°=4 acres, it follows that 4 acres divided by the product of one half the natl. sine of 56° into A C, gives B C the required side. Thus:

c

50×4=200 perches ×, 4145188=82.9; and 640 perches in 4 acres, divided by 82.9=7.72 per the length of B C, and in like manner any other similar case can be done.

17th. Sometimes it is found necessary to obtain the area of a trapezium from having the diagonals and the angle of intersection given.

Rule—Half the product of the diagonals multiplied by the natural sine of the angle of intersection, will be the area.

EXAMPLE.

If the two diagonals of a trapezium be 40.15, and 60.13 chains the ∠ of intersection 75° 45′, what is the area. $\frac{1}{2}$ of 40.15×60.13=1207.1097= half the product of the diagonals, and 1207.1097× 96923=(natural sine of 75°45′)=1169.966934531= the area, in square four pole chains, or 116. 3. 39. 47. (A. R. P.) Answer.

18th. To find the area of a trapezium, when each side and the angle of intersection of the diagonals are given. *Rule*—Square each side of the trapezium; add together the squares of each pair of opposite sides; subtract the less from the greater; multiply the difference by the tangents of the angle of intersection. One fourth of the product will be the area.

EXAMPLE.

What is the area of a trapezium, the sides of which are 10, 13, 7.16, 8.32, and 10.05 chains respectively, and the ∠ of intersection of the diagonals 52° 15′.

$(10.13)^2 = 102.6169$
$(\ 8.32)^2 = \ 69.2224$

171.8393=Sum of sqs. of opposite sides.

$(15.05)^2 = 226.5025$
$(\ 7.16)^2 = \ 51.2656$

277.7681=Sum of sqs. of other sides.

105.9288 Difference,
Multiplied by .32288=$\frac{1}{4}$ the natural tangent,

34.20290944 or

A 3. 1 .27,23 perches.

For a demonstration of the foregoing, see *Gibson's Surveying, by Trotter.*

19th. To find the area of a trapezium, when the four sides are severally given, and also the sum of any two opposite angles. *Rule*—From half the sum of the four given sides, subtract each severally; multiply the four remainders continually together; from the result subtract one half the continual product of the four sides, multiplied by unity, increased by the natural cosine of the sum of the given angles. The square root of the result will be the area.

Remark.

In the application of this theorem, it must be carefully remembered that the cosine of an angle is positive when that angle is in either the first or fourth quadrants, and negative when it is in the second or third quadrants. For a demonstration of this beautiful theorem, see also, *Gibson, by Trotter.*

N. B. When the sum of the opposite angles is 180°, that is, when the trapezium can be inscribed in a circle, the above rule is simply: from half the sum of the given sides, subtract each side severally; multiply the four remainders continually together, and extract the square root, gives the area.

Example.

"One morning in May I went to survey,
As soon as bright Sol I espied;
I measured round a four cornered ground,
In the margin see the length of each side;
The angle at B, together with D,
An hundred and fifty degrees;
The meadow's content is all that I want,
Assist me kind youths, if you please."

A B 15.60
B C 13.20
C D 10.00
D A 26.00 ch'ns.

2)64.80 sum.

32.4=$\frac{1}{2}$ sum.

16.80=1st remr.
19.20=2d do.
22.40=3d do.
6.40=4th do.

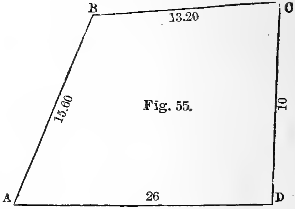


Fig. 55.

S=half the sum. of the sides.

Whence (s–A B)×(s–B C)×(s–C D)×(s–D A)= 32.4×16.8×19.2×22.4×6.4=46242.2016=46242. 2016

$$\text{And } \frac{\text{A B. B C. C D. D A.}\times(1+\cos.\ 150^\circ)}{2}$$

$$\text{That is } \frac{15.60\times13.20\times10.00\times26.00}{2}\times0.1339746=3586.4464$$

Difference=42655.7552

The square root of 42655.7552 is 206, 5327= area in square four pole chains, or 20. 2. 24,55232. (A. R. P.)

N. B. This problem is taken from Deighan's Arithmetic, vol. second. page 148, and the answer there given is 21. 2. 00,64 (A. R. P.), which is obtained by taking the trapezium to be inscribed in a circle, which is not the case.

When the opposite angles of a quadralateral are equal to two right angles, a circle can be described about it. The rule to find the area, then, is : multiply the half sum, and four remainders continually together, and extract the square root, for in that case $1+\cos.(A+B)=0$.

21st. To find the area of a circle having the diameter given. *Rule*—Square the diameter, and multiply by .7854, and you have the area.

22d. To find the area of an ellipsis. *Rule*—Multiply the transverse and conjugate diameters together, and that product by .7854, and you have the area.

23d. To find the area of a parabola. *Rule*—Multiply the height by the breadth, and take two-thirds of the product; you have the area.

24th. To find the area of a segment of a parabola. *Rule*—Multiply the base of the segment by the altitude thereof, and two-thirds of the product gives the area.

25th. To find the area of a field or lot, which is found to be the frustum or zone of a parabola, included by two parallel right lines, and the intercepted curves of the parabola. *Rule*—Add the two

parallel ends, divide the square of either of these ends by this sum, add the quotient to the other end, multiply this sum by the altitude of the frustum or distance of the ends, take two-thirds of the product, and it gives the area.

TRIGONOMETRICAL SURVEYING.

26th. It was not my intention to say any thing concerning this branch of surveying, as it is too extensive a subject for this small work; but as some young readers may not have met with any thing on that subject, I will present them with an outline of how that grand operation is conducted.

When an entire country, or part of a country, containing one or more counties is to be surveyed, it is done by triangulation, and the application of the rule given in the 12th section of this work. A line of some miles in length is measured and re-measured in order to prove its accuracy, on some plane or heath which is nearly level, first having been traced by a transit instrument, and poles placed in an exact straight line, to guide the measurers, as A B in the annexed figure, which is assumed as the base of the operations. A number of hills and elevated spots are selected, on which signals can be placed, suitably distant and visible

one from another. Thus, if A C D E B H G F, &c., be several objects, the situations of which

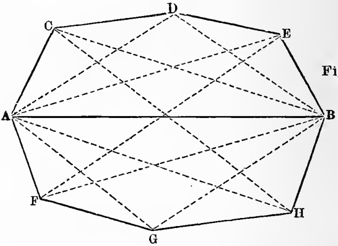


Fig. 56.

are to be laid down on a map, and they are within the lines, A C D E B H G F, accurately calculated. It is supposed that the stations A and B are chosen such as that all the others can be seen from each of them. Then from the extremity A, measure the angles E A B, D A B, C A B, &c., H A B, G A B, F A B, &c. And from the other extremity B, measure the angles, C B A, D B A, E B A, &c., F B A, G B A, H B A, &c. And as the common base, A B, and the several angles of all the triangles are now known, the sides, A C, A D, A E, &c. may be determined by simple proportion, for as the natural sine of

A C B : A B :: sine C A B : C B and so is sine A B C to C A, and so through all the triangles, the three sides being thus found in each triangle, the area is easily found, as shown in section 8th of this treatise. But to insure accuracy the objects C D E, etc., should be all intersected from some third station, ⊙ in the base A B, otherwise the figure may appear in the plotting to be right when it is not so, and there will be no means of knowing whether the angles have been correctly taken without going over the work again.

27th. Here follows an example of a triangle containing a mean area of 1135.2.12.79 (A. R. P.). The sides of which were traced by a transit instrument, and poles placed at the several points marked thus ⊙; this being done, the respective distances of the sides were ascertained by a mean of measures as follows, viz:

B A 14643 links, or 9664.38 feet, A C 17814 links, or 11777.24 feet, B C 16588 links, or 10948.08 feet. The angles were taken by a theodolite as they are marked in the figure.

Now to determine the area of the triangle, A B C:

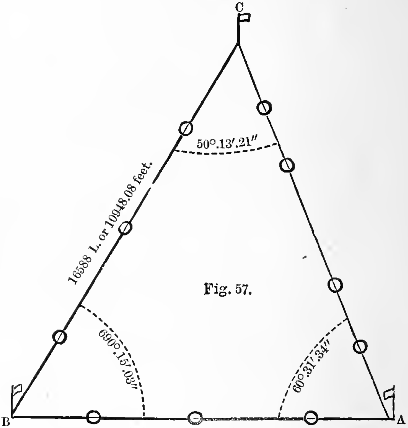


Fig. 57.

1st. From the data, A B, and the three angles of the known formula

$$\frac{A\,B^2 \times \text{sine } B \times \text{sine } A,}{2 \text{ sine } C.} = \overset{\text{A.}}{1135}.\overset{\text{R.}}{2}.\overset{\text{P.}}{27.18}$$

2d, by B C, and the three angles, the area will be 1135.3.0.29

3d, by C A, and the three angles, the area will be 1135.0.38.6

4th, by data A B, and the two adjacent angles, we have by the known formula,	
$\dfrac{A\ B^2 \times \text{sine } B \times \text{sine } A,}{2 \text{ sine } (B+A)}$	
	A. R. P
The area will be	1135.2.25.7
5th, and by B C, and the two adjacent angles	1135.3.01.9
6th, by a similar formula from A C, and the two adjacent angles, the area will be	1135.0.37.99
7th, by data A B, and the adjacent angle A, and the remote angle C, we have by the known formula,	
$\dfrac{(A\ B)^2 \times \text{sine } A \times \text{sine } (C+A)}{2 \text{ sine } C.}$ area,	1135.2.27.8
8th, by a similar formula from having A B, and the angles, B and C; area	1135.2 28.2
9th, by having C B and the angles, C and A; area	1135.3.03.58
10th, by having C B and the angles B and A; area	1135.3.04.38

11th, by a similar formula data C A, and the angles, C and B, gives the area	A. R. P. 1135.0.39.66
12th, by a similar formula from data C A, and the angles A and B; area	1135.1.00.12
13th, by data A B×B C, and the contained angle, we have	

$$\frac{\text{A B}\times\text{B C}\times\text{sine B}}{2}=1135.2.35.06$$

14th, by A C×A B, and the contained angle	1135.1.32.92
15th, by A C×B C, and their contained angle C	1135.2.00.79

16th, by data, A B×B C, and the angle, A, we have by a known formula, $\frac{\text{B A}\times\text{sine A}}{\text{B C.}}=$

$$=\text{sine C, and } \frac{\text{A B}\times\text{B C, sine (A+C)}}{2} \text{ area } 1135.2.394$$

17th, by the application of similar formula to the data, A B×B C, and angle, C; area	1135.2.30.4

		A. R. P.
18th, by A C×C B, and angle, A,		1136.0.19.51
19th, by A C×B C, and angle, B, the area will be		1135.0.19.89
20th, by A C×B A, and angle, B, the area will be		1135.1.10.5
21st, by A C×B A, and angle, C, the area will be		1135.3.05.16
22d, by the usual rule from the three sides,	s. s—a. s—b. s—c.	1135.2.14.7

Now the various data exhibited in this triangle have been ascertained with the same relative degree of precision; and the different areas deduced therefrom have been subjected to the same logarithmic process, till the figure has been exhausted; there is no reason to suppose that any one of them is nearer to the truth than another; and taking a mean of the results we have 1135.2.12.97 (A. R. P.) for the nearest approximation to the true area.

But suppose we consider the triangle as spherical, and the admeasurement of the sides as the lengths of three arcs of three great circles of the sphere; and, according to Sir Isaac Newton, the diameter of the earth to be 41,798,177 feet. we will then have, as the circumference of a great

circle of the earth is to 360°, so is the length of C B to the number of degrees or minutes, &c., contained in the arch, C B, viz:

As 131312964.37	: 360° ::	11757.24 :	1′.56″.03868=	arch	C A.
And do.	: do. ::	9664.38 :	1′.35″.38309=	"	A B
And do.	: do. ::	10948.08 :	1′.48″.05263=	"	B C.

Now let b a c, represent the sides of any spherical triangle, and e the spherical excess, we have by Lhuiller's theorem, Tangent $\frac{1}{4}$ E=

$$\text{Tan.}\ \frac{a+b+c}{4}.\ \text{tan.}\ \frac{a+b-c}{4}.\ \text{tan.}\ \frac{a-b+c}{4}.\ \text{tan.}\ \frac{-a+b+c}{4}.$$

And by restoring to a b and c, their determined values, we find

$$\frac{a+b+c}{4}=0°\ .1'\ .19''.\ 8686$$

$$\frac{a+b-c}{4}=0°\ .0'\ .32''\ .1771$$

$$\frac{a-b+c}{4}=0°\ .0'\ .21''\ .8493$$

And, $$\frac{-a+b+c}{4}=0°\ .0'\ .25''\ .8423$$

Whence the log. tangt. of 0° .1′ .19″ .8686=	6.5879531
of 0 .0′ .32″ .1771=	6.1931205
of 0 .0′ .21″ .8493=	6.0250065
of 0 .0′ .25″ .8423=	6.0979010
	2)24.9039811
Log. of $\frac{1}{4}$ the spherical excess=	2.4519905

The arc corresponding to this log. will be found

to be ,00584 parts of a second, consequently the spherical excess is 02336 of a second, and by a well known theorem, As 180° : the area of one-quarter the surface of the sphere : : the spherical excess to the area of the spherical triangle, viz:

As 180° 31500428420,3 the area of a great circle of the earth in statute acres : : 023360 to $\overset{\text{A.}}{1135}.\overset{\text{R.}}{2}.\overset{\text{P.}}{11}.3$ being $\frac{1}{2}$ perch less than the mean area, which is in defect, but should be in excess; but this is accounted for by the hills on the land not being taken into account; the difference, however, is insignificant, and shows that the difference between a plane and spherical triangle of considerable dimensions is very inconsiderable. See *Gibson's Surveying by Trotter.*

28th. How to measure a tract of land by measuring a base line through it, and not departing from that line, and yet finding all the distances round the land, their courses, and angles of the field, and the area, never before published.

In order to do this expeditiously, the surveyor should be provided with an instrument having two telescopes, one of which is movable, and the other fixed, by which he can at any time take half a right

angle from the base line, and also a right angle; he must also have an active assistant with a flag-staff, to hold at the corners as he proceeds with the measurement on the base line. Let A B C D E T M G H A be any tract of land that is to be surveyed, let the base K L, be traced through it with a transit instrument, and poles set perpendicularly, to be visible from one to another. Set your instrument at L, on the base line, which in this survey bears N 40 E. A theodolite and compass attached is the best instrument for this method; adjust your instrument, and let L be the point where 45° inflected from the base L K will cut the flag-staff; at the corner H, commence chaining towards K, and five chains you find 45° degrees deflected from the base line to the flag-staff at B, on the left, will bisect it, which note in your field-book by an oblique line to the left, making an angle as near 45° as the eye can judge; at 9.30 half a right angle to the right will cut a pole at G, and at 12.00 came the fence; at 13.20 half a right angle will cut C, and at $\overset{\text{C. L.}}{19.15}$ you find a right angle will intersect H. Now it is evident that you are $\overset{\text{C. L.}}{19.15}$ distant from H, for H 19.15. L

is an isosceles triangle, and ∴ you mark $\overset{\text{C. L.}}{19.15}$ on the perpendicular. The next perpendicular is at

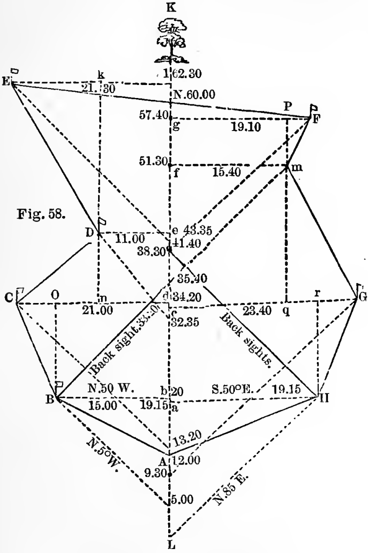


Fig. 58.

20, and the half right angle having been taken at $\overset{\text{C.}}{5}$ on the chain line, 20—5=15=the distance to B. Again at $\overset{\text{C. L.}}{32.35}$ you find half a right angle bisects

the pole at D, and at 33.20 a right angle intersects at G, and 33.20—9.30=$\overset{\text{C. L.}}{30.40}$=the length of the perpendicular which set on it. At 34.20 you find the next perpendicular on the left to C, and the one-half right angle having been taken at 13. 20 ∴ 34.20—13.20=$\overset{\text{C. L.}}{21.00}$ the distance to C; proceeding in this way you have 43.35—32.35=11 chains to D, and 51.30—35,40=15.40=the distance to M, and 57.40—38.30=19.10 to F, and 60—57.40=2.10=the perpendicular of the last △ within the fence on the right and 62.30—60=2.30= the perpendicular without the fence; also, 62.30—41=21.30=the distance to E, which △ is to be ducted out of the area of the last trapezoid on the left. Thus you have found with very little trouble all the requisites for calculating the area of the land, and it may be remarked, that you might have commenced at the corner B and noted where the two perpendiculars fell at 19.15 and 20 and as you proceeded on your base line take back sights at the proper distances to intersect the poles at B and H, and the distances from where the perpendiculars would fall to these several points would be the chains and links to be placed thereon. The dis-

tances all round the land, can be accurately found, for in the present case $\sqrt{(A\ a^2)+(a\ H^2)} =$ A H, and r G, and r H being given $\sqrt{(r\ G^2)+(r\ H^2)} =$ H G and so on all round the land, and seeing that the courses of A a and a H are given, the course of A H may be readily found, for having the distance and difference of latitude and departure, the course is given in the tables; also, the internal angles can be easily found, for in the $\triangle$ A a H A a : Rad. : : a H : tang't a A H, and so with the $\triangle$ B b A. Hence, the angle B A H, is known, and it is evident the same holds good all round the land, the bases and perpendiculars of all the right angled triangles being found from the base line and can be marked on the sketch as the surveyor proceeds. The same may be done with a good compass, for having the course of the base line, the courses of the normals to right and left are known, and the course of $\frac{1}{2}$ a right angle being once ascertained on the right and left of the base will always serve to find the points on the base where they are to be taken; but this would require many trials and waste time, whereas, an instrument showing $\frac{1}{2}$ a right angle will save much time.

Thus, in a plane country, the scientific reader will acknowledge the plan completely available, and the surveyor can calculate the content of the land on the margin of his book while his needle is settling, and be able to answer the farmer satisfactorily, who thinks a surveyor should be able to tell the content the moment he has the last distance measured.

The plotting and calculation of a survey taken on the above plan is so obvious as to require no explanation, seeing all the figures are either right angled triangles or trapezoids, to find the area of which is shown in figure 53.

29th. The most correct method of correcting the difference of latitude and departure in surveys taken with the compass, to fit them for calculation, some authors divide the differences proportionally among all the stations; but as there may be some stations in a survey really correct, any alteration in them would make them incorrect, so that the altering of the legs of stations in surveys where land is of great value, is a matter of considerable importance.

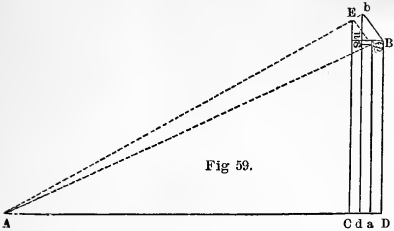


Fig 59.

Problem.

To find what may be the error in the difference of latitude and departure of a given station arising from the inaccuracy of practice:

Let the right angled triangle A B D, fig. 59, represent a station with its difference of latitude and departure; if the angle A be the bearing, then will the leg A D, be the difference of latitude, and the leg B D, the departure; but if the angle at B be the bearing, then will the leg B D, be the difference of latitude, and D A the departure. Let the small angle B A b represent the error committed in taking the bearing, which may amount $7\frac{1}{2}$ minutes, and the small part B e or E b, the error committed in chaining, in proportion to the whole line A B, or A e, as 0.5 is to 5.00, (for in measuring the

length of lines, there may be an error committed of half a link in 10 chains; (this is found by experience), and let e a, b d, and E c be drawn parallel to B D, and B n o, and r e s, parallel to D A.

Case 1*st*. Suppose A B to be the true bearing and length of a station, and A b the one found by observation. Now it is plain that instead of the triangle A B D, we shall have by observation the triangle A b d, so that there is an error of the quantity n b, by which the leg B D is increased, and an error of the quantity B n, by which the leg A D is decreased, and the contrary may be supposed, if A b be the true distance and bearing and A B that found by observation; but when the angle at A is very small, D d may be supposed equal to (O).

Case 2*d*. Suppose the true length and bearing of a station to be A e, and that found by measurment to be A B the bearing exact. Now it is plain that the leg e a is increased by the error r B, and that the leg A a, is increased by the error r e or a D, and the quantities or errors by which each leg is increased are in proportion to the legs

themselves, that is, B r : e a : : r e : A a, and as B e is to A e.

Case 3d. Suppose A e the true bearing and length of a station, and A b the same, found by observation. This supposes a compound error both in chaining and bearing, and that the error in the bearing increases the smallest angle in respect of the bearing and its complement. Here we see that when the leg A a is increased to A D by the error in chaining, as in the last case, it shall, at the same time, be brought back to A d by the error in the bearing, as in case 1st. Therefore, the leg A a will be increased by the quantity r e—B n, or decreased by the quantity B n—r e; but r e is greater than B n, when the angle at A is small; and B n is greater than r e, when the angle is near 45°; for they become equal when the angle. is about 25°; but at the same time the leg e a will be increased to d b, by the error b S=b n+B r.

Case 4th. Suppose A E the true distance and bearing, and A B that found by observation; this supposes the error in the bearing to decrease the smallest angle. Now it is evident that the longer leg A c is increased by the error B o or D c, and

the shorter leg decreased by the error E o. But B o=B n+r e (for r e=n o) and E o=b n– -B r. These errors are easily found in numbers by considering the figure, and that they are always proportional to the length of the stations.

Here follows a table of errors in links and decimals, calculated for a station of 30 two pole chains, and for the different angles and their complements, under which they are placed, but which can be changed to any other length, by altering them in the same proportion as are the stations.

B A b=⅛°error in bearing.	2° 88	12° 78	23° 67	32° 58	42° 48	° 45	B e 1.5 links error in chaining.	
b n=	3.2	3.1	3.0	2.8	2.4	2.3	Error in short Leg.	Case
B n=	0.0	0.7	1.4	1.7	2.2	2.3	Error in long Leg.	1st.
B r=	0.0	0.3	0.6	0.8	1.0	1.0	Error in short Leg.	Case
r e=	1.5	1.5	1.4	1.3	1.1	1.0	Error in long Leg.	2d.
b s=(b n+B r)	3.2	3.4	3.6	3.6	3.4	3.3	Error in short Leg.	Case
a d=(B n∽r e)	1.5	0.8	0.0	0.4	1.1	1.3	Error in long Leg.	3d.
E o=(b n–B r)	3.2	2.8	2.4	2.0	1.4	1.3	Error in short Leg.	Caso
B o=(Bn+r e)	1.5	2.2	2.8	3.0	3.3	3.3	Error in long Leg.	4th.

Corrollary.

Hence we may adopt the following rules for altering the legs of stations in the correcting of surveys:

Rule First.

When the course, or angle, is either great or small; or when the difference of latitude and departure are found in the beginning of the tables, then the shortest leg may be increased or decreased by any quantity not greater than 3.2 links, and the longest leg increased by any quantity not greater than 1.5 links.

Rule Second.

When the latitude and departure are found about the middle of the tables, or when the angle is about 20° under or over 45°, then the shortest leg may be increased by any quantity not greater than 3.6, or rather 4 links, and the longest leg left unaltered, which is, when the error in the bearing increases the angle opposite the smallest side; but when contrary, the longer leg may be increased by any quantity not greater than 3 links, and the shorter leg decreased by 2 links.

Rule Third.

When the difference of latitude and departure are found in the latter part of the tables, or when the bearing is about 45°, then either of the legs

(they being nearly equal) may be increased or decreased by any quantity not greater than 3 links, and the other leg by 1.4 links, but when one leg is increased the other must be decreased.

These rules are on the supposition that the chaining is always too long, which, in practice, I have nearly always found to be the case; but when a surveyor has reason to think otherwise, he may alter the rules to his opinion, not only in respect to this, but also relative to the quantity of the errors.

A description of an instrument by which any person, though unskilled in surveying, may measure a map, or part of a map, almost at one view:

Get a piece of good glass about 8 or 9 inches long, and 6 or 7 inches broad, and divide it into small oblong rectangles of eight-tenths of an inch by 5 five-tenths, as fig. 60th. By laying this instrument (which I call a *computor*) on a map you can tell with very few figures, sometimes with the eye only, how many of the rectangles are contained in the map, and consequently, how many acres. When the map is laid down by a scale of 20 perches to an inch, then each rectangle will be

16 perches by 10, or one acre; and if the map be 40 perches to an inch, then each rectangle will be 32 perches by 20, or 4 acres; and if by 80 perches to an inch, then each rectangle will contain 16 acres. This instrument would be useful to gentlemen and others not very well skilled in surveying, to measure a map, or part of a map that they wished to know the content of nearly. It is easily used. The sides of the glass must be made to coincide with as many of the lines on the map as possible, and the broken squares can be estimated by the eye, or a square inch horn.

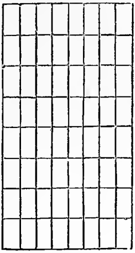


Fig. 60.

Description and design of a new instrument by which distances can be found at once, without any calculation:

Let a brass semi-circle (fig. 61) of about 9 inches radius, have its inner edge or limb, divided into 90 equal parts, beginning at N and counting upwards 10, 20, 30, &c., to 90 at Z, and each of these divisions subdivided into 6 equal parts. Let

the outer limb be divided into degrees and 6th parts of a degree, marking the degrees from the middle of the limb, both ways, 10, 20, 30, &c., to 90 at N and Z. Let also, the middle space between the outer and inner limbs, be marked from Z to N, 10, 20, 30, 40, &c., to 180 at N.

Let this semi-circle be fixed to the middle of a box ruler B D, about 3½ feet long, an inch and a half broad, and of a convenient thickness. The inner breadth of half this rule must be level with the surface of the semi-circle, but the outer half must be higher about two-tenths of an inch. On the outer half there must be fixed a thin brass scale of an equal length and breadth with the box ruler, the breadth of which scale is to be divided, by lines drawn from end to end, into three equal parts, and the length into inches, half inches, and tenth of an inch; the inches are to be drawn directly across the whole breadth, and marked 1, 2, 3, 4, &c., both ways to B and D; the half inches are to be drawn across the middle and innermost third, and the 10ths only across the inner third. Let there be on one end of this scale an inch, and on the other end half an inch, each divided very

exactly into 10 equal parts diagonally, that the 10ths and centesms which may happen in the operations, on the square and indices hereafter to be described, may be exactly measured on them by a pair of dividers. The reason for raising the outer half of the box ruler above the inner half two-tenths of an inch, is to make room for the indices A b and A d, which are to be fixed to the centre of the semi-circle, and there to open and shut as occasion requires, like the legs of a sector. Those indices are about 26 inches long, three-fourths of an inch broad, and about two-tenths thick; their breadth is to be divided into three equal parts, and their length into inches, half inches, and tenths, as the brass scale before mentioned. The inches are to be marked from the center A, with 1, 2, 3, 4, &c., to b and d, and the tenths drawn across the inner third. Each of those indices must have a small screw nut with a pin or bit of wire upon it, which pin may, by the screw nut, be fixed exactly to any division on them in order to suspend the label, or ruler T Y, which has a thin piece of brass with a small hole in it, exactly fitting the aforesaid pin, and is to be fixed

also to any division of the ruler, as occasion requires. Let this label, or ruler, be about two feet long, and of the same breadth and thickness as the indices A b and A d, and divided after the same manner as they are, only the tenths are to be drawn across the inner edge, as well as across the inner third of the breadth, and the inches are to be marked 1, 2, 3, 4, &c., from C to T and Y, making C T eighteen inches, and C Y six. The like divisions are to be made on the side of the square K X, beginning at the inner edge of the brass ruler at K, marking the full inches on the upper side, 1, 2, 3, 4, &c., to 24; the tenths are to be drawn across the upper third and the upper edge. Let this instrument be fixed on a tripod with a ball and socket like those of a common surveying instrument, but very strong, in order to have it very firm; and let there be sights which may, as occasion requires, be fixed on the diameter, indices, and ruler T Y, of the the same kind with those of a surveying instrument.

N. B. The ball and socket must not be fixed exactly under the center of the semi-circle, but some distance from it, on the cross-bar which goes from

the center to the middle of the limb, as well to support the head of the instrument more easily by being nearer its center of gravity, as to make room for an air level, which must be fixed exactly under the diameter or ruler A B, so that when the semicircle is turned vertically the diameter may be fixed horizontally.

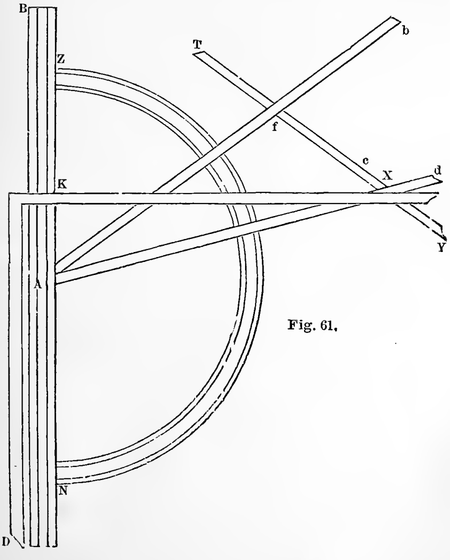


Fig. 61.

The use of the Instrument in measuring distances:

EXAMPLE.

Let it be required to find the distance from the house at A to the castle, (fig. 62) or to any part thereof, as the weather-cock on the top of the spire at C.

Having set up your instrument at A, turn it about till through the sights on the diameter, you see a mark set up at B, and having fixed the diameter in that position, turn the moving index till through the narrow slit of a small sight fixed on the center, you see the hair in the other sight cut the spire at C, then fixing the index in that position to the limb of the semi-circle, measure with a four pole chain in a straight line from A to B; and having marked the chains and links of that distance on the diameter and placed the ruler with the sights on it exactly to that distance, by means of the small pin and hole mentioned before, set up your instrument at the end of the distance you measured (which you may make full chains if you please) and turn it about till through the sights on the diameter you see a pole at the first station A, and having fixed it in that position, turn the ruler on the pin which is fixed at the former distance on

the diameter, till through the sights on it you see the vane at C; then will the part of the index a c, cut by the inner edge of the ruler, give the distance A C from the house to the spire at C, which was to be found; and if there be occasion, the distance from the mark at B to the spire will be found on the ruler at the intersection of the index; all of which is plain from the similarity of the triangles A B C and a. pin. c, or that formed by the diameter, index, and ruler, from Cor. 1st 4 Euc. Book 6th. Thus the surveyor can find the distance of any or all the particular objects he can see and may wish to set down in his map, and by turning the instrument vertically by means of a notch in the socket, inaccessible heigths can, in like manner, be readily ascertained in the same manner.

Example in Measuring Distance.

Let it be required to find the distance from the house at A to the castle, (fig. 62) or to any part thereof, as the weather-cock at the top of the spire at C.

Having set up your instrument at A, turn it about till through the sights on the diameter, you see a pole at B, and having fixed the diameter in

that position, turn the moving index till through the narrow slit of a small sight fixed on the center, you see the hair in the other sight cut the spire at C; then fix the index in that position to the limb of the semi-circle and measure with your chain of 100 links in a straight line from A to B, which mark on the diameter, and place the ruler, having the sights on it exactly on that distance by means of the small pin and hole before mentioned; set up the instrument at the end of the measured distance, and turn it about till through the sights on

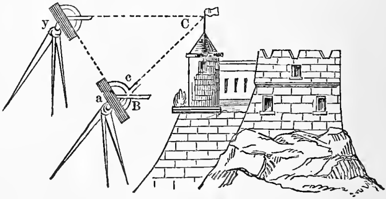


Fig. 62.

the diameter you bisect the pole at A, and having fixed it in that position, turn the ruler on the pin which is fixed at the former distance on the diameter, till through the sights you see the vane at C; then will the part of the index, a c, cut by the in-

ner edge of the ruler, give the distance A C from the house to the spire at C.

And in like manner by directing the ruler to any other objects from A, and noting the degrees cut by the ruler on the limb, and directing from B to each object, the distance from A will be shown as before explained, and thus the surveyor furnished with such an instrument, can from the end of his first station, tell the length of his diagonals to as many corners as he can see from that point. Also, by turning the instrument vertically, heights can be determined in the same manner.

I would recommend the surveyor to use a compass, having the limb divided into 360°, and the bottom of the box into four 90's; then in taking the courses, if N. W., the limb and quarter compass are the same; but if in the S. W. quarter, the sum of the degrees on the limb and quarter compass are 180°; and in S. E. quarter, the difference of the degrees on the limb and quarter compass make 180°; lastly, if in the N. E. quarter, the sum of the quarter compass and limb make 360. A surveyor should prove all his courses by this rule before he quits his instrument.

PROBLEM.

Given the bearings of any two stations of a survey, thence to determine the angle made by those stations. *Rule*—Deduct the preceding bearing from the succeeding, according as the remainder is greater or less than 180°. Add—or+180° (as the case may be) and you have the required angle.

N. B. The angle found by the above rule will be internal if the polygon lie towards the right hand in the traverse; and external, if toward the left.

EXAMPLE FIRST.

Required the several angles of the polygon A B C D E F G, the courses of the sides being, viz.

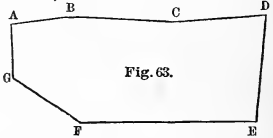


Fig. 63.

1	A B	$269\frac{1}{2}°$	or	S. E. $89\frac{1}{2}°$
2	B C	$251\frac{1}{2}$	or	S. E. $71\frac{1}{2}$
3	C D	$252\frac{3}{4}$	or	S. E. $72\frac{3}{4}$
4	D E	$162\frac{1}{4}$	or	S. W. $17\frac{3}{4}$
5	E F	$77\frac{3}{4}$	or	N. W. $77\frac{3}{4}$
6	F G	$30\frac{3}{4}$	or	N. W. $30\frac{3}{4}$
7	G A	$5\frac{3}{4}$	or	N. W. $5\frac{3}{4}$

From	$251\frac{1}{2}$	From	$77\frac{3}{4}$
take	$269\frac{1}{2}$	take	$162\frac{1}{4}$
	-18		$-84\frac{1}{2}$
	$+180$		$+180$
Sum	162 = Ang. A B C.	Sum	$95\frac{1}{2} = \angle$ D E F

From	$252\frac{3}{4}$	From	$30\frac{3}{4}$
take	$251\frac{1}{2}$	take	$77\frac{3}{4}$
	$+1\frac{1}{4}$		-47
	$+180$		$+180$
Sum	$181\frac{1}{4} = \angle$ B C D.	Sum	$133 = \angle$ E F G

From	$162\frac{1}{4}$	From	$5\frac{3}{4}$
take	$252\frac{3}{4}$	take	$30\frac{3}{4}$
	$-90\frac{1}{2}$		-25
	$+180$		$+180$
Sum	$89\frac{1}{2} = \angle$ C D E.	Sum	$155 = \angle$ F G A

From	$269\frac{1}{2}$
take	$5\frac{3}{4}$
Rem.	$263\frac{1}{2}$
	-180
Sum	$83\frac{1}{2} = \angle$ G A B

Now 180° multiplied by the number of sides in

any polygon minus 360°, equals the sum of the internal angles $\therefore$ $180 \times 7 = 160$ and $1260 - 360 = 900$ So $83\frac{3}{4}+162+181\frac{1}{4}+89\frac{1}{2}+95\frac{1}{2}+133+155=900°$. Proof.

Next. Having the bearing of any station and all the internal angles of any polygon, thence to determine the courses of each of the other stations in the regular order of succession, viz: the land lying to the right hand as you surround it. *Rule:* According as the given angle is + or — than 180°; add the preceding bearing, succeeding angle, and + or — 180° (as the case may be;) their sum will be the succeeding bearing or course.

NOTE.—It sometimes happens that the result will be more than 360°; in this case take 360° from it and the remainder will be the course of the succeeding station.

EXAMPLE.

Take the course of A B $269\frac{1}{2}$ or S. $89\frac{1}{2}$ E, in the preceding figure, and the angles as there found, viz:

$269\frac{1}{2}$
162
$+180$

$611\frac{1}{2}$
Deduct 360

Cou. of B C $251\frac{1}{2}$ or S $71\frac{1}{2}$ E.

$251\frac{1}{2}$
$181\frac{1}{4}$
-180

Cou. of C D $252\frac{3}{4}$ or S $72\frac{3}{4}$ E.

$252\frac{3}{4}$
$89\frac{1}{2}$
$+180$

$522\frac{1}{4}$
Deduct 360

Cou. of D E $162\frac{1}{4}$ or S $17\frac{3}{4}$ W.

$162\frac{1}{4}$
$95\frac{1}{2}$
$+180$

$437\frac{3}{4}$
360

Cou. of E F $77\frac{3}{4}$ or N $77\frac{3}{4}$ W

$77\frac{3}{4}$
133
$+180$

$390\frac{3}{4}$
360

Cou. of F G $30\frac{3}{4}$ or N $30\frac{3}{4}$ W

$30\frac{3}{4}$
155
$+180$

$365\frac{3}{4}$
360

Cou. of G A $5\frac{3}{4}$ or N. $5\frac{3}{4}$ W.

$5\frac{3}{4}$
$83\frac{3}{4}$
$+180$

Cou. of A B $269\frac{1}{2}$ or S $89\frac{1}{2}$ E.

being the same as that given; therefore, a proof of the correctness of the work. And thus the surveyor has a sure method of avoiding the inconvenience of the needle being drawn from its true position by mines or other causes, and also correct the diurnal variation; for no matter how much

the needle may be attracted at any station, the angle will be correct by taking a back and fore sight at every station, and having the true course of the first station. All the others can be found by the foregoing rules. And to know if any attraction exists at the first station, take a course in a different direction from your chain line; go to the object bisected, or to some convenient distance in that direction, and take a back sight; if that agree with the fore sight, you may safely conclude that no attraction exists at either; but should it differ, make trial in some other direction, in like manner, till you find what station the attraction is in; but by using a good theodolite all such trouble is avoided.

In every survey that is truly taken, the sum of the Northings is equal to the sum of the Southings, and the sum of the Eastings to the sum of the Westings.

Let a b c e f g h represent a plot or parcel of land; let a be the first station, b the second, c the third, and so on. Let N S be a meridian line, then will all lines parallel thereto, which pass through the

several stations, be meridians also, as a o, b s, c d, &c., and the lines b o, c s, d e, &c., perpendiculars to these, will be east or west lines or departure.

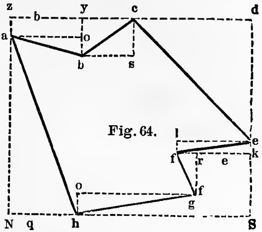


Fig. 64.

The northings e i+g o+h g=a o+b s+c d+f r, the southings; for let the figure be completed, then it is plain that g o+h g+r k=a o+b s+c d and e i—r k=f r; if to the former part of this first equation e i—r k, be added, and f r to the latter, then g o+h g+e i=a o+b s+c d+f r; that is, the sum of the northing is equal to the sum of the southings.

The eastings c s+q a=o b+d e+i f+r g+o h, the westings for a q+y o (a z)=d e+i f+r g+o h, and h o=c s—y o. If to the former part of this first equation c s—y o, be added, and b o to the latter, then c s+a q=o h+d e+i f+r g+o h; that is, the sum of the eastings is equal to the sum of the westings.

Now, as there is many methods of calculation, and every man chooses one in preference to all

others, I shall here show the method which I have always practiced, being, I think, least liable to mistakes, although not the shortest, as shall be hereafter shown.

No. of station.	Course.	Distance. Chs. Lks.	N.	S.	Lat. 11.00	Lats. added	E. area.	W. area.	E.	W.
1	N. 63½ W.	2.24	1.00	.....	12.00	23.00	....	46.0000	.....	2.00
2	N. 56¼ E.	3.60	2.00	.....	14.00	26.00	78.0000	....	3.00	.....
3	N. 26½ E.	2.24	2.00	.....	16.00	30.00	30.0000	....	1.00	.....
4	S. 71½ E.	3.16	.....	1.00	15.00	31.00	93.0000	....	3.00	.....
5	S. 26½ E.	2.24	.....	2.00	13.00	28.00	28.0000	....	1.00	.....
6	S. 71½ W.	3.16	.....	1.00	12.00	25.00	....	75.0000	.....	3.00
7	S. 45 E.	1.41	.....	1.00	11.00	23.00	23.0000	....	1.00	.....
8	S. 63½ E.	2.24	.....	1.00	10.00	21.00	42.0000	....	2.00	.....
9	N. 45 E.	1.41	1.00	.....	11.00	21.00	21.0000	....	1.00	.....
10	S. 26½ E.	2.24	.....	2.00	9.00	20.00	20.0000	....	1.00	.....
11	S. 45 W.	1.41	.....	1.00	8.00	17.00	....	17.0000	.....	1.00
12	S. 63½ W.	2.24	.....	1.00	7.00	15.00	....	30.0000	.....	2.00
13	N. 45 W.	2.83	2.00	.....	9.00	16.00	....	32.0000	.....	2.00
14	S. 63½ W.	2.24	.....	1.00	8.00	17.00	....	34.0000	.....	2.00
15	N. 26½ W.	3.16	3.00	.....	11.00	19.00	....	19.0000	.....	1.00
			11.00	11.00	.....	.....	....	....	13.00	13.00

Sum of the East areas, 335.0000 253.0000
Sum of the West areas, 253.0000

2) 82

41 The content.

In the above method the northings and south ings, eastings and westings, being corrected by the

foregoing rules, set the sum of the northings, or southings at the top of the column titled latitude, then continually add the northings and subtract the southings, or add the southings and subtract the northings, and the last number will always be the same as the first, which is a proof of so much of the work. Then add the first and last latitudes together, and place their sum opposite to the first station in the column under latitudes, added, and so continue to add every two adjoining latitudes, and place their sum in a line with the latter, then multiply each of these numbers by the particular easting or westing belonging to that station, and place the product in the column of east or west area, as the case may be, and the difference of these two columns divided by two, will be the content of the survey. In this method there is no danger of making mistakes from indirect stations, and by using the eastings, and westings, in the same manner as you did the northings, and the southings, you can prove the work, and find the area four different ways.

ANOTHER METHOD, WHEREIN FEWER FIGURES ARE USED, NEVER BEFORE PUBLISHED:

The Eastings and Westings, Northings and Southings, are here corrected according to the foregoing rules, and placed as usual, as follows:

CALCULATION OF THE NOTES ON THE SUCCEEDING PAGE.

	N.	S.	L. N.	L. S.	Lats. added.	Doub. Semi Rectangle.	E.	W.	
1	....	2.76	2.76	......	2.76	+4.4712	1.62	......	
2	....	4.44	7.20	5.15	9.96	+11.9520	1.20	Ex.E	
3	....	0.77	......	4.38	9.53	+20.5848	......	2.16	
4	Ex. S.	4.38	......	0.00	4.38	— 1.9272	0.44	......	Indirect
5	2.60	....	......	2.60	2.60	14.3520	......	5.52	
6	0.36	....	......	2.96	6.56	—10.3416	1.86	......	Indirect
7	3.35	....	6.04	6.31	9.27	+59.1426	Ex.W	6.38	
8	3.34	....	2.70	......	8.74	+17.4800	2.00	......	
9	2.11	....	0.59	......	3.29	—4.4086	......	1.34	Indirect.
10	....	0.40	0.99	......	1.58	+5.6564	3.58	......	
11	....	2.53	3.52	......	4.51	+5.4120	1.20	......	
12	1.75	....	1.77	......	5.29	+5.0784	0.96	......	
13	1.77	Ex. N.	0.00	......	1.77	+4.4958	2.54	......	
	15.28	15.28				165.3026	15.40	15.40	
	Double the sum of the indirect,					33.3548			
						131.9478			
						65.9739 Angular spaces.			

```
         11.76 Parallel breadth.
         12.35 Meridianal breadth.
         -----
          5880
         3528
        2352
       1176
       ---------
       145.2360 Content of parallelogram.
        65.9739
       --------
       7,9.2621
              4
       --------
        3.70484
             40
       --------
       28.19360
```

A. R. P.
7.3.28.19, the same as on next page.

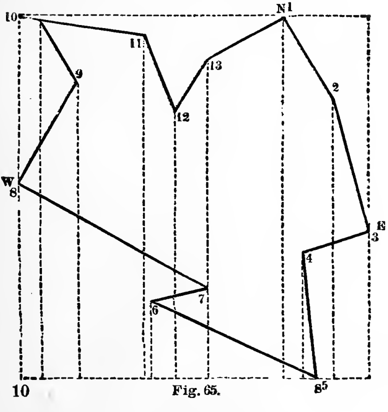


Fig. 65.

The foregoing plot and calculation may not be unacceptable to the reader, being as complicated a figure as could be easily met with.

A new and concise method of Calculation, wherein fewer figures are used than in the common methods:

	N.	S.	E.	W.	M. D. 162	D. D.	Area.	Deduction.
1	....	2.76	1.62	....	3.24 E.	4.86 E.	13.4136	....
2	....	4.44	1.20	....	4.44 E.	7.68 E.	34.0992	....
3	....	0.77	....	2.16	2.28 E.	6.72 E.	5.1744	....
4	....	4.38	0.44	....	2.72 E.	5.00 E.	21.9000	....
5	2.60	....	....	5.52	2.80 W.	0.08 W.	2080	....
6	0.36	....	1.86	....	0.94 W.	3.74 W.	1.3464	....
7	3.35	....	....	6.38	7.32 W.	8.26 W.	27.6710	....
8	3.34	....	2.00	....	5.32 W.	12.64 W.	42.2176	....
9	2.11	....	....	1.34	6.66 W.	11.98 W.	25.2778	....
10	....	0.40	3.58	....	3.08 W.	9.74 W.	....	3.8960
11	....	2.53	1.20	....	1.88 W.	4.96 W.	....	12.5488
12	1.75	....	0.96	....	0.92 W.	2.80 W.	4.9000	....
13	1.77	....	2.54	....	1.62 E.	0.70 E.	....	1.2390
	15.28	15.28	15.40	15.40			176.2080	17.6838

$$
\begin{array}{r}
176.2080 \\
17.6838 \\
\hline
2,0)15,8.5242 \\
\hline
7,9.2621 \\
4 \\
\hline
3,7.0484 \\
40 \\
\hline
28.19360
\end{array}
$$

A.	R.	P.
7	3	28.19

This method may be called a compound of Burgh's and Gibson's, without being intimately connected with either. It allows the first meridian to pass at any distance from the first station not less than the first latitude or first departure.

This example supposes the first meridian to pass at the distance of the first Easting from the first station of the survey, and the M. D. column is completed by one single addition of the Eastings, or one single subtraction of the Westings, to or from each preceding one, agreeably to the nature of the signs. The D. D., or double distance column, is completed by adding the first and last, and placing their sum in a line with the first Easting or Westing, and then adding every two according to the signs, and placing their sum in a line with the latter, marking E. or W. as the case may be. Then the Eastings $\times$ by the Southings, and the Westings $\times$ by the Northings, must be put into the area column; but, the Westings $\times$ by the Southings, and the Eastings $\times$ by the Northings, must be put into the deduction column, the difference is double the area of the survey.

The following is a method of calculation first published by Noble, the inventor, and is a very superior plan when well understood, but requires considerable attention to distinguish the indirect stations, as the areas belonging to them must be deducted. A little practice will enable the learner to know both them and the four extremes, viz:

N. S. E. and W. That author's description of a semi-rectangle is a figure limited by the latitudes of both ends of the station, the station itself, and a section of the parallel from which the latitudes are measured, equal to the departure; and when the last mentioned is indirect, the semi-rectangle is indirect also, viz: Indirect or retrograde stations are those stations, in respect of the rest, which bear backward or contrary to the natural succession of the four quarters of the compass.

If, in proceeding Southerly from the extreme point North, there happen a station to turn Northerly, or, in proceeding Northerly from the extreme point South, there happen a station to turn Southerly, such stations are indirect or retrograde stations. The same may be said of stations that turn after the like manner in proceeding from the extreme points E. and W. of the survey. The extreme points, N. S. E. or W. of a survey, are the ends of those stations which run more to the N. S. E. or W. than any other stations in the survey.

Though most surveys have those four extreme points, yet there are some where one and the same station may be the greatest extreme N., and at the same time the greatest extreme East or West;

or one and the same station may be the extreme South, and likewise the extreme East or West. The circumscribing parallelogram of a survey is a rectangle or parallelogram circumscribing the body of the land, whose four sides, passing through the four extremes N. S. E. and W. of the survey, are two meridians and two parallels of latitude.

The angular spaces are the areas contained between the sides of the circumscribing paralellogram, and the stations of the land surrounded, which, deducted from the area of the second parallelogram, leaves the content of the survey.

Now in order to find the area of those angular spaces, the four extremes must first be ascertained. This an experienced hand can see at once by examining his field-book, which, being known, you must find the latitude of each station in the survey from the extreme points North and South; thus, having found and corrected your latitudes and departures, and placed them as in the following table, write O in a line with N, and also the South extreme as in the following table. Now, beginning at each of these extremes, North and South, continue to add the Northings, and subtract the Southings to find the latitude of each station to

the extreme point West, but you must still add the Southings and subtract the Northings to the extreme point East. When the latitude of every station is thus found, and placed in their proper columns, add every two latitudes next each other, and put their sum in a line with the latter station in the column marked L. A., and each sum or number in this column is the length of a rectangle, which is double the semi-rectangle of each station. It is no matter at which of the two latitudes you begin, so that you place their sum in a line with the latter or succeeding station; but it is common to begin by adding the first and last stations together, and placing their sum in a line with the first station; then add the first and second, and place it in a line with the second, and so on till the column is filled. Then each number must be multiplied by its corresponding Easting or Westing, and the products put in the column marked D. S., or double semi-rectangle of each station. If the Easting or Westing be direct, then this product must be marked +; but if it be indirect, with the negative sign —, and the sum of all the affirmatives, abating the sum of all the negatives, will be the content of all the angular

spaces. But, to find the length and breadth of the circumscribing parallelogram, note that from the sum of all the Northings or Southings you must deduct the sum of all the Northings or Southings that have indirect difference of latitude, which will give one side, and the same must be done with the Eastings and Westings to find the other side. The length and breadth of the parallelogram being thus found, they must be multiplied together, and from their product take the content of the angular spaces, and the remainder will be the content of the survey.

TAKE THE FOLLOWING EXAMPLE IN NUMBERS.

	N.	S.	L. N.	L. S.	L. A.		E.	W.
1	....	5.75	....	0.00	5.75	+076.5900	....	13.32
2	30.28	....	....	30.28	30.28	+468.7344	....	15.48
3	9.23	....	....	39.51	69.79	+687.4315	....	9.85
4	9.04	....	6.17	48.55	88.06	+626.1066	....	7.11
5	4.66	....	1.51	....	7.68	+088.9344	11.58	....
6	1 51	....	0.00	....	1.51	+020.2340	13.40	....
7	....	6.78	6.78	....	6.78	+049.8330	7.35	....
8	....	17.46	24.24	....	31.02	+268.3230	8.65	....
9	....	12.97	37.21	....	61.45	— 233.5100	....	3.80
10	....	11.76	48.97	5.75	86.18	+739.4244	8.58	....
	54.72	54.72				2)2792.1013	49.56	49.56
						1396.0506=Ang. spaces.		

In this example there are no indirect stations in the Northings or Southings, 54.72 is the meridianal breadth of the survey. But station 9th being indirect in the parallel breadth, must be

deducted from the sum of the Easting or Westing to find the other side of the circumscribing parallelogram. Thus:

```
   49.56 Sum E. or W.
    3.80 Indirect.
  ------
  45.76=Parallel breadth.
  54.72=Meridianal breadth.
  ------
  91.52
 32032
18304
22880
---------
2503.9872 Content of circum. parallelogram.
1396.0506    "    of the angular spaces.
---------
1107.9366
        4
---------
  3.17464
       40
---------                 A. R.  P.
  6.98560              110.3.06.98, the content.
```

In this example you may see that the four extremes are the 6th, 1st, 10th, and 4th stations You can also see that the two latitudes of the extreme West is equal to the two latitudes of the extreme East, that is 6.17+48.55=48.97+5.75, which is a proof to so much of the work.

If you begin with the Eastings and Westings, and proceed as you were directed, all along with the Northings and Southings, you can find the content of the survey in like manner, and so prove the work.

To survey with the compass through any mine, or other cause for drawing the compass needle off its parallelism :

The diurnal variation of the needle is known to every practical surveyor, but is easily corrected by examining the time of the day when the courses of long stations were taken ; as from about 8 o'clock in the morning till about 2 in the afternoon, the needle varies Westerly to from about 7′08″ to about 13′21″, as shown in the following table. The surveyor can make such allowance as will (all other errors apart) insure a complete clase.

MEAN DIURNAL VARIATION FOR EVERY MONTH IN THE YEAR.

January,	0″ 7′08″	July,	0″13′14″
February,	0 8′58″	August,	0 12′19″
March,	0 11′17″	September,	0 11′43″
April,	0 12′26″	October,	0 10′36″
May,	0 13′00″	November,	0 8′09″
June,	0 13′21″	December,	0 6′58″

Now, in surveying with the compass detached from a Theodolite, both back and fore sights should always be taken ; and to make sure that no attraction exists in the first station, take a course in a contrary direction to some object, go to that object and take a back sight ; if the fore and back sight agree you may be satisfied that no attraction is at your first station ; but should they not agree, you must then, from the latter station, repeat the like process till you find at which of them the attraction exists ; if, at the first station, either note its quantity, which allow on the next course, as in tracing old boundaries ; or pay no attention to it at the starting, but continue to take the fore and back sights throughout, and as at any station the needle will be as much attracted at the fore as the back sight, the angles can all be truly found as formerly shown, and thence the true courses for calculation by latitude and departure. Thus may the expert surveyor traverse any city, mountain, or other place containing mines or other substances which attract the needle, about which I have heard many complaints.

Now to plot the last given notes, and in like manner any other survey similarly prepared :—Having the length and breadth of the circumscribing parallelogram, let it be drawn by the same

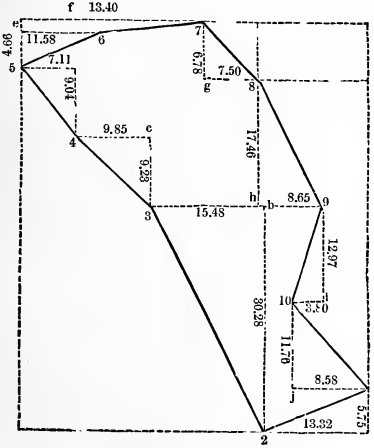


Fig. 66.

scale you intend to lay down your map by, and beginning at either of the extremes, as 1, lay off your latitude as 1.a 5.575, and at right angles to that, the departure of that station or Westing a.2 13.32, and join their extremities with the line 1 2,

which is the distance. The next station is N. W. Draw toward the North 2.b parallel to the sides of your parallelogram, and on it lay 30.28, your next Northing, and at right angles thereto toward the West 15.48, your next Westing, and join 2 and 3, which is your next distance, and so on all round, and as your Northings are equal to your Southings, and your Eastings to your Westings, your last departure, whether East or West, will fall into the point of beginning, as T.1. This is the most expeditious mode of plotting surveys, and can be made use of in the most extensive work, and is much superior to protraction by parallels and a metallic protractor. The mechanical methods of finding area, shown by many authors, I do not think well to notice, as none of them can be depended on for accuracy.

OF LOTTING OR LAYING OUT TOWNS, &C.

Regarding this kind of surveying, little can be said more than giving some general directions concerning the method of operation, as every man has mostly predetermined the manner in which he intends to have his property cut up into lots. Provide yourself with a 20 or 25 feet pole, ten

skivers with sharp points and thin edges, two brass plummets with steel points hung to fine cords; then having fixed poles so as to direct you in a straight line, and set them perpendicular by the help of your plumb, direct your assistant to hold one end of your pole in the straight course, with his plummet hanging over the extremity, whilst you hold yours touching the end of the pole which you hold, and the point of your plummet exactly over the starting point; when both plummets are steady, order your assistant to stick, and exactly where the point sticks, he sticks one of his skivers edgewise and slanting, so as that you can, when you arrive at it, hang the point of your plummet exactly over the edge of the skiver, and your assistant again sticks his plummet in the ground, and a skiver as before, and so on to the end. By measuring carefully in this manner, property can be laid out with great accuracy.

Almost every man has his own method of keeping his field-book, but the following method, which I have always adopted, is, I think, best calculated to prevent confusion in extensive surveys, for as writing backward and chaining forward are contrary, it is more congenial, and natural, to both

write and chain forward, by beginning at the bottom of the page.

N. B. It may not be unacceptable to the reader to see these notes, calculated by Noble's method, as on page 119.

Maple	60.00 35.10 N.77¾W. (5)	Pin Oak 0.5
W. O. Stump. Tustan's Land.	41.40 162¼ S.17¾W. (4)	
Sugar 0.6	36.40 33.00	To a stone.
	21.00	
	15.00 7.00 252¾ S. 72¾E. (3)	S. O. 0.10 toChesnut
Heirs. B. Oak O'Hara's	41.00 26.00 4.00 251¾ S. 71¾E. (2)	To a post. Dogwood
	20.00 269½ S. 89½E. (1)	chains to a hickory tree.

Samuel Furguson.	18.48	To the place of beginning.
	7.10 3.24 N. 5¾ E. (7)	R. O. 0.15 to a Pine
Edward Kinsley.	36.25	To a post.
		Chesnut.
	23.00 10.00 7.00 N.30¾W. (6)	0.10 to a Beech
	66.00 62.00	Shellbark Hickory. Stream North 36 West.

Begins at a White Oak on Squire Hays' Estate.

The foregoing method of keeping a field book, I think, is the most convenient I have seen. The following is the calculation of the notes corrected by the foregoing rules.

		F. Poles.	N.	S.	Lat. 32.05	L.A.	E. Area.	W. Area.	E.	W.
1	S. 89½	10.00		0.10	31.95	64.00	640.0000		10.00	
2	S. 71¾ E.	20.50		6.55	25.40	57.35	1115.4575		19.45	
3	S. 72¾ E.	18.40		5.50	19.90	45.30	795.9210		17.57	
4	S. 17¾ W.	20.90		19.90	0.00	19.90		126.9620		6.38
5	N. 77¾ W.	33.00	6.94		6.94	6.94		223.8150		32.25
6	N. 30¾ W.	18.25	15.68		22.62	29.56		275.7948		9.33
7	N. 5¾ E.	9.48	9.43		32.05	54.67	51.3898		0.94	
			32.05	32.05			2602.7683	626.5718	47.96	47.96

626.5718

Double area, 2.0)1976.1965 in square four pole chains.

98.800825
4

3.239300
40

9.572000

A. R. P.
98.3.0957

N.	S.	Lat. South.	Lat. North.	Lats. Added.	Double Semi-rectangles.	E.	W.
	0.10		0.10	0.10	—1.0000	10.00	
	6.55		6.65	6.75	+131.2875	19.45	
	5.50	19.90	12.15	18.80	+330.3160	17.57	Ex. E.
Ex. S.	19.90	00.00		19.90	—128.9620		6.38
6.94		6.94		6.94	+223.8150		32.25
15 68		22.62	9.43	29.56	+275.7948	Ex. W.	9.33
9.43	North.		00.00	9.43	+8.8642	0.94	
32.05	32.05				2)1098.0395	47 96	47.96

Content of the angular spaces, 549.0197

```
   47.96 Parallel breadth.
   32.05
   ------
   23980
  9592
 14388
 ----------
 1537.1180 Content of circum. parallelogram.
  549.0197     "    of the angular spaces.
 ----------
  988.0983
         4
 ----------
  3.23932
       40          A. R. P.
  ---------        98.3.95.73 the same as before.
  9,57280
```

There are no indirect stations in the above, but were the longitudes made use of instead of the latitudes, the last station would be indirect; and here also it may be seen that the sum of the opposite latitudes, against the extremes East and West, are equal, viz: 12.15+19.90=32.05 and 22.62+9.43=32.05.

Of the Tracing of Old Mearings.

Gummer, in his work on Surveying, gives the general number 57.3°, for doing this which many

work with, although it is not correct, but comes out pretty near the truth when the chain line is not very long.

To find this number, say 6.2831853 (the circumference of a circle whose diameter is 2) : 360° :: 1 : 57.3° nearly. Now if two corners are known, and can be both seen, set your compass at one of them, and direct your sights to the other; the difference between that shown by your needle, and that shown in the deed, will be the variation to be allowed on each course round the land, supposing all those given in the deed to have been correctly taken at the time the survey was made, which frequently happens not to be the case. If the two corners cannot be seen from each other, run the course and distance given in the deed, and observe if the point you arrive at, joined to the corner, form an isosceles triangle, which will be the case if all be right; otherwise some mistake has been made in the distances, which must be corrected. Then take the pendicular distance to the given corner, and say: As the measured distance is to the distance to the corner, so are 57.3° to the number of degrees, minutes, or seconds, as the case may be, which will be the variation. Or,

more accurately. As the distance to where the perpendicular was taken is to radius, so is the distance to the corner to the tangent of the variation. In running your trial line, you will be told you are wrong, and that you don't understand your business, and all such stuff, will be sounded in your ears; but pay no attention to such nonsense, for it is to be regretted that too many men are so ignorant as to think that a Surveyor can, by some mysterious means, direct his compass on the exact line, and find all the courses as if by magic. It often happens that the corners runs through clumps of trees or other obstructions through which you cannot chain. In such a case I have often chosen an opening some degrees to right or left of the fence, and at certain distances driven posts till I found a perpendicular to the corner. Then, as the whole distance is to the perpendicular, so is each distance from the beginning to the perpendicular distance from the measured line to the fence, which, being correctly laid off, and posts driven at their extremities, will point out the true boundary.

Of Levelling.

The art of levelling consists in finding or tra-

cing a line on a given portion of the earth's surface, parallel to the horizon at all points. The subject is too extensive to be comprised in this small treatise. I shall give an example, which it is hoped will enable the reader to do anything of that nature that may come in his way. Any one desirous of being fully informed on that subject, should consult Bruff's Engineering, where every information on that subject can be obtained. Regarding the adjustment of the level, which is a simple matter, let the practitioner always place his level in the middle, between the back and foresights, and keep the bubble in the middle of the divisions, and all will be right.

FIELD BOOK DISTANCES, MEASURED WITH A ONE HUNDRED FEET CHAIN.

Elevation.	Back sight.	Fore sight.	Depression.	Total elevat'n Datum 100 feet.	Distance.	Remarks.
				100.	0 .00	
1.11	6.84	5.73	....	101.11	100	
....	5.73	8.10	2.37	98.74	100	On cross road 50
....	8.10	8.15	0.05	98.69	100	ft. W. N. 54 W.
2.35	8.15	5.80	....	101.04	100	Side of ravine, 30
0.80	5.80	5.00	....	101.84	100	feet deep.
0.45	5.00	4.55	....	102.29	100	10. bottom 10 ft. wd.
0.96	5.01	4.05	....	103.25	100	Top of bank on
....	4.05	4.98	0.93	102.32	100	other side.
....	4.98	6.12	1.14	101.18	100	
....	6.12	6.67	.55	100.63	100	
....	2.25	7.77	5.52	95.11	100	
....	7.77	13.52	5.75	89.36	100	Middle of stream,
....	3.95	6.30	2.35	87.01	100	N. 57 W.
....	6.30	10.80	4.50	82.51	100	
....	1.60	4.24	2.64	79.87	100	
....	4.24	6.74	2.50	77.37	100	
....	6.74	10.20	3.46	73.91	100	
....	2.17	4.60	2.43	71.48	100	
....	4.60	5.36	0.76	70.72	100	
....	5.36	5.99	0.63	70.09	100	
5.67	104.76	134.67	35.58	100....	Datum at top, from which the reduced level is deducted, giving a third proof of the accuracy of the work.	
		104.76	5.67	70.09		
		29.91	29.91	29.91		

The fall in the following section from 1 to 21 is 29.91 feet; this divided into 2100 feet, the whole distance gives 1 in 70.21, the regular grade; and to find the grade in degrees, it will be as 2100 is to radius :: 29.91 to the tangent of the angle in this case 0° 49′ nearly. Here it will be observed

that the difference between the datum line and any grade, is the height above or below the base line, running through the first station. If the ordinate be greater, the difference is above base; if less, below. Some old fashioned levellers follow a more intricate plan. Thus 101.11—98.74=2.37—1.11 =1.26 above; again, 98.74—98.69=0.05, and 1.26+0.05=131 below, and so on. But this requires too much thought, when to add and when to subtract; whereas the other method is done by one subtraction.

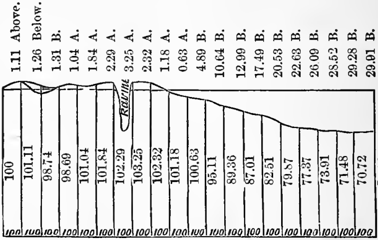


Fig. 67.

Scale of length, 800 feet to an inch—of height, 100 feet.

To lay out a Road on a Regular Grade up a Hill.

Set your instrument at the starting point, level it, and set the vane on your levelling rod to the exact height of the centre of your glass. Ele-

vate your grading instrument to the number of degrees you intend your road to be. Send forward your rod to any place where the cross wire will cut the middle of the vane, and there drive a post, and on it mark grade, and so on to the end of the road. *And to find the cuttings and fillings, the following plan is the most convenient.* Set your instrument on the starting point, measure very exactly the height of the centre of the glass, and send your rod to the first point where cutting or filling is required. Elevate your instrument to the grade, mark where it cuts the rod, and the difference of the height of the instrument and height on the rod, will be the cutting or filling. If the height of the instrument exceeds that on the rod, the difference is cutting, and per contra.

EXAMPLE:

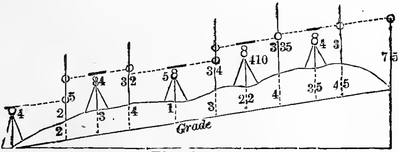


Fig. 68.

In the above cut the height of instrument is 4 feet; height of rod, 2; difference, 2 cutting.

Again, height of instrument, 4, and back sight to rod 5; difference, 1 to be added to last, gives 3 of cutting at instrument. Fore sight, 3; difference to be added to last, gives 4 feet cutting at the rod; but now, height of instrument, 5; back sight, 2; difference, 3; which, deducted from 4, leaves 1, and so through the whole.

To Inflect in Curves on Rail Roads and Others.

The curves most in use at the present time, are those of a circle. The angle made at the angular point of the tangents is always given—the length of your tangent is also given. To find the radius, multiply the natural tangent of half the contained angle by the length of the tangent of your curve, and the product will be the radius of the curve.

To find the degree of curvature, divide half the chord to be inflected by the radius of the curve, and it gives the natural sine of the degrees of curvature.

Thus, in the annexed figure, where the radius is 140, and the cord to be inflected 100. 140)50, 000000 (.357142 is the natural sine of 20° 55′ = the degrees of curvature.

Demonstration.

The angle A D C, is a right ∠=to A D B, and A C B is common to the two triangles, A B C and A D B. Hence ∠ A C D=B A D$\frac{1}{2}$, the ∠ angle of deflection. Now set your instrument at A, direct your index to E, turn it towards the curve

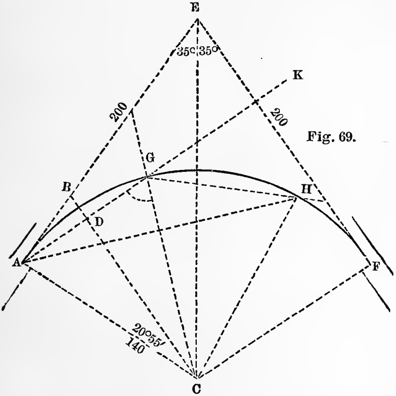


Fig. 69.

till 20° 55′ are told on the limb, holding the end of your chain at A; let the assistant hold the chain tight, and move round till the other end comes in the line of the perpendicular wire of the

telescope at G, and then fix a pin. Again, if nothing intervene to prevent your seeing, inflect from A E, double the said ∠, and fixing one end of the chain at G, let the other be stretched to come in contact with the telescope at H, and so on through the whole. If H cannot be seen from A, move the instrument to G, and take a back sight to A, and inflect double the ∠ of the degrees of curvature from G K, which will fall into H.

I have met with some calling themselves engineers, who adopt the following plan. They divide 57.,3°×60=3438′ by the radius of the circle, multiplying the quotient by the number of feet in the chord, and divide by 60 for double the angle; but this is erroneous. I remember having met with a person who declared that the angle found by this rule was the true angle of deflection. I gave him the tangent 100, and the radius 100 feet, and he did it by this rule, viz: 100)3438(34.38×100=3438+60=57° 18′. In this instance the ∠ made by the tangent and chord is only 45°, so that instead of inflecting in 100 feet, this 57° 18′ would fall below the chord. Nor is the half of it correct, viz: 28° 39′. For by the true method 100)50(=,5, the natural sine of 30° the true angle.

It remains to find the length of the curve A G H F. The circumference of a circle whose diameter is 2, is 6.2832 nearly. Hence as 360° : 6.2832 :: 1 : .01745, &c. This number, multiplied by the degrees in the arc, and by the radius of the curve, gives the length of the arc, thus:

01745	
11	
17450	$268.\frac{73}{100}$ the length of the arc, and
1745	so of any other.
1,91950	
140	
7678000	
191950	
268,73000	

The two following problems may be amusing to some readers, viz:

A gentleman has a lot 40 perches long and 30 perches wide. He thinks the ends may be so applied, as that when their extremities are joined, the area may be the greatest possible. The perpen-

dicular breadth, and the length of the unknown side are required.

Answer: Breadth, 26.815 nearly.

Length of the unknown side, 66.904 nearly.

PROBLEM SECOND.

A plank road is to be made from the city A to the town B, 20 miles asunder. A straight road is so situated that a perpendicular from A to it is 10 miles, and from B 6 miles. The plank road must touch the straight road in such a point as to be the shortest possible by that route, the length of the plank road, the point of contact, and radius of the curve having 200 feet tangent, are required.

Answer: Length of the plank road, 25.298

The distance of the point of contact from A, 12.2474

And from B, 7.3484

Radius of the curve having 200 feet tangent, 245 feet nearly.

This note to be placed after the calculation of the large triangle. It is there shown that the area of any plane triangle, the three sides of which are given, is $\dfrac{AB^2 . \text{ Sine B. Sine A}}{2 \text{ Sine C.}}$ C Which it thus proved B△A

It has been already shown that $\frac{B\,C.\ B\,A.\ \text{Sine } B.}{2}$ equal area of the triangle, $\therefore \frac{B\,C.\ A\,C.\ \text{Sine } C.}{2}=\text{area}.$

Hence B C. B A. Sine B=B C. A C. Sine C.

Multiply each side by B A, and we have

B C. B A^2. Sine B=B C. A C. B A. Sine C.

Divide this equation by B C, we have

B A^2. Sine B=A C. B A. Sine C.

Multiply each side by Sine A $\therefore$

B A^2. Sine B. Sine A=A C. B A. Sine A. Sine C.

Divide this by Sine C, and

$$\frac{B\,A^2.\ \text{Sine } B.\ \text{Sine } A.}{\text{Sine } C}=A\,C.\ B\,A.\ \text{Sine } A.=\text{twice}$$

the area, and therefore

$$\frac{A\,B^2.\ \text{Sine } B.\ \text{Sine } A}{2\ \text{Sine } C}=\text{Area}$$

To find the perpendicular ordinates from the chord 6 of any arc of a railroad, in order to set off the curve correctly and speedily, without the help of an instrument, suppose it to be a 20° curve, the tangent 200. Find the radius, as formerly taught; multiply the radius by the natural co. sine of half the vertical angle, and you have ½ the chord.

Multiply the radius by the natural sine of the same angle, and you have the distance from the centre to the middle of the chord, a constant number to be deducted. Now take any distance, suppose 10 feet, at which you choose to erect your

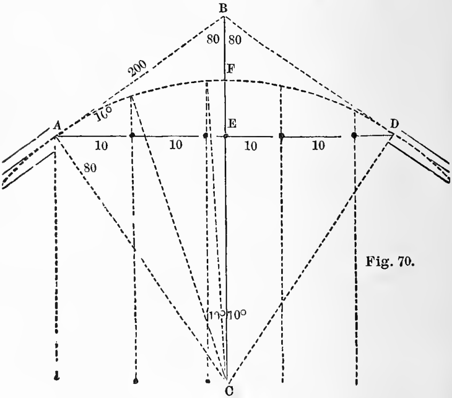


Fig. 70.

ordinates, and from the semi-chord subtract this number, square the remainder, and subtract it from the square of the radius; extract the square root, from which take the aforesaid constant number, and the remainder is the ordinate to be rightly applied, and so proceed till you arrive at

the middle of the chord; then the difference between the said constant number and the radius, is the versed sine or greatest ordinate, and now you are prepared to lay off the other side of your curve, and all this can be done in a few minutes in the field.

EXAMPLE. See last figure.

```
Nat. tangent of 80°=5.67128
                        200
                 ----------
                 1134,25600=Radius, 1134.
Nat. co. sine of 80°  =,17365
                 ----------
                    5671280
                   6805536
                  3402768
                 7939792
                1134256
                -----------
                196,96355440=Semi-chord, 197.
                ===========
Nat. sine of 80°     1134
                     ,9848
                    ------
                      9072
                     4536
                    9072
                   10206
                   -------
                  1116,7632 Distance from centre to said chord=1117.
```

From 1134
Take 1117

17=Versed sine FE—From 197
Take 10

$(187)^2=34969$

From $(1134)^2=1285956$
Take $(\ 187)^2=\ \ 34969$

1250987=1118
From which take 1117

1 ft. the 1st ordinate.

Again, for the 2d ordinate, $197-20=(177)^2$
$=31329$ and 1285956
— 31329

(1120 From 1120
√1254627 Take 1117
1

3=the next.

21)25
21

222)446
444

2240)227

Ordinate. All this is plain from the figure, and when the radius and constant subtrahend are

found (which is only the work of a minute) all the others are nearly had at sight. This I consider quite superior to any other method now in practice

Otherwise thus: Let the radius, versed sine, chord, and constant quantity D E, be found as

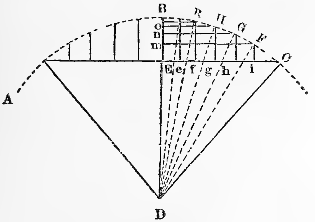


Fig. 71.

before, divide the semi-chord into any number of parts as e f g h i. From E C deduct one of the parts i C, leaves E i=m F, then D F=(radius) squared—$(m\ F)^2=(m\ D)^2$ the square root of which, minus the constant quantity, E D, gives the ordinate i F, and in like manner all the others are found, and thus the curve can be laid off in a few minutes in the most accurate manner, (by the 47th of the first of Euclid.)

PROBLEM.

Let A B C be a right angled triangle, the hypothenuse of which is 35, and the difference between the area of the enscribed square (one of whose angles coincides with the right angle of the triangle) and the area of the △ is 150. Required the sides of the triangle.

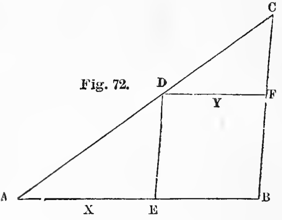


Fig. 72.

SOLUTION.

Put A E=x and D F=y. Then per 4th Euc. 6th, y : y :: x : $\frac{y^2}{x}$=C F, $\frac{y^3}{x}$+x y=Double the area of the △s A D E and D F C ∴=300 or $\frac{2y^3}{x}+2\,x\,y=600$. Also $\frac{y^2}{x}$+ Y=B C and x+y = A B. Now $(\frac{y^2}{x}+y)^2+(x+y)^2=35^2$ viz: $\frac{y^4}{x^2}+\frac{2y^3}{x}+y^2+{}^2y^2+2\,x\,y=1225$

$$\text{Deduct} \qquad \frac{2y^3}{x} \qquad +2\,x\,y=600$$

$$\frac{y^4}{x^2}+2\,y^2+x^2=625 \text{ Ex't the square.}$$

$$\text{Root and} \qquad \frac{y^2}{x}+x=25 \text{ or}$$

$$y^2+x^2=25\,x=A\,D^2=5\,\sqrt{x}.$$

Hence $5 \sqrt{x} : x :: 35 : x+y$, and by dividing the first and third by 5, $x^{\frac{1}{2}} : x :: y \; x+y$ and :: are their squares. $x : x^3 :: 49 . x^2+y^2+2xy$. Multiply the extremes and means, and

$$49 x^2 = x^3 + x y^2 + 2 x^2 y \div \text{by } x \text{ and}$$

From $49 x = x^2 + y^2 = 2 x y$; but $25 x = y^2 + x^2$.·.
Take $25 x = x^2 + y^2$

$$24 x = 2 x y \quad \text{or}$$
$$24 = 2 y \quad \text{and}$$
$$y = 12 \text{ the side of the square.}$$

And the sides of the angle are 21 and 28.

$$\begin{array}{r} 28 \\ 21 \\ \hline 28 \\ 56 \\ \hline 2)588 \\ \hline 294 \end{array} = \text{area of } \triangle.$$

$$\begin{array}{rr} \text{Deduct,} & 144 \\ \hline & 150 \end{array} = \text{area of the } 2 \triangle\text{'s}.$$

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
			0¼	19¾	0½	89½	0¾	89¼
1			0.9999	0.0043	0.9999	0.0087	0.9999	0.0131
2			1.9999	0.0087	1.9999	0.0174	1.9998	0.0262
3			2.9999	0.0131	2.9998	0.0261	2.9997	0.0392
4			3.9999	0.0174	3.9998	0.0349	3.9996	0.0523
5			4.9999	0.0218	4.9998	0.0436	4.9995	0.0654
6			5.9999	0.0262	5.9997	0.0523	5.9994	0.0785
7			6.9999	0.0305	6.9997	0.0611	6.9993	0.0916
8			7.9999	0.0349	7.9997	0.0698	7.9992	0.1047
9			8.9999	0.0393	8.9996	0.0785	8.9991	0.1178
	1°	89°	1¼	88¾	1½	88½	1¾	88¼
1	0.9998	0.0174	0.9997	0.0218	0.9996	0.0262	0.9995	0.0305
2	1.9997	0.0349	1.9995	0.0436	1.9993	0.0523	1.9990	0.0610
3	2.9995	0.0523	2.9993	0.0654	2.9989	0.0785	2.9986	0.0916
4	3.9994	0.0698	3.9990	0.0872	3.9986	0.1047	3.9981	0.1221
5	4.9992	0.0872	4.9988	0.1090	4.9982	0.1309	4.9976	0.1527
6	5.9991	0.1047	5.9985	0.1309	5.9979	0.1570	5.9972	0.1832
7	6.9989	0.1221	6.9983	0.1527	6.9976	0.1832	6.9967	0.2137
8	7.9988	0.1396	7.9981	0.1745	7.9972	0.2094	7.9962	0.2443
9	8.9886	0.1570	8.9978	0.1963	8.9969	0.2356	8.9958	0.2748
	2°	88°	2¼	87¾	2½	87½	2¾	87¼
1	0.9994	0.0349	0.9992	0.0392	0.9990	0.0436	0.9988	0.0479
2	1.9987	0.0698	1.9984	0.0785	1.9981	0.0872	1.9977	0.0959
3	2.9981	0.1047	2.9977	0.1178	2.9971	0.1308	2.9965	0.1439
4	3.9975	0.1396	3.9969	0.1570	3.9962	0.1745	3.9954	0.1919
5	4.9969	0.1745	4.9961	0.1963	4.9952	0.2181	4.9942	0.2399
6	5.9963	0.2094	5.9954	0.2355	5.9943	0.2617	5.9931	0.2878
7	6.9957	0.2443	6.9946	0.2748	6.9933	0.3053	6.9919	0.3358
8	7.9951	0.2792	7.9938	0.3141	7.9924	0.3489	7.9908	0.3838
9	8.9945	0.3141	8.9930	0.3533	8.9914	0.3926	8.9896	0.4318
	3°	87°	3¼°	86¾	3½	86½	3¾	86¼
1	0.9986	0.0523	0.9984	0.0567	0.9981	0.0610	0.9978	0.0654
2	1.9973	0.1047	1.9968	0.1134	1.9963	0.1221	1.9957	0.1308
3	2.9959	0.1570	2.9952	0.1701	2.9944	0.1831	2.9936	0.1962
4	3.9945	0.2093	3.9935	0.2268	3.9925	0.2242	3.9914	0.2616
5	4.9931	0.2617	4.9919	0.2835	4.9907	0.3052	4.9893	0.3270
6	5.9918	0.3140	5.9903	0.3402	5.9888	0.3663	5.9871	0.3924
7	6.9904	0.3664	6.9888	0.3968	6.9869	0.4273	6.9850	0.4578
8	7.9890	0.4187	7.9871	0.4535	7.9851	0.4884	7.9829	0.5232
9	8.9877	0.4710	8.9855	0.5102	9.9832	0.5494	8.9807	0.5886
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	4°	86°	4¼	85¾	4½	85½	4¾	85¼
1	0.9976	0.0698	0.9972	0.0741	0.9969	0.0784	0.9965	0.0828
2	1.9951	0.1395	1.9945	0.1482	1.9938	0.1569	1.9931	0.1656
3	2.9927	0.2093	2.9917	0.2223	2.9907	0.2354	2.9897	0.2484
4	3.9902	0.2790	3.9890	0.2964	3.9977	0.3138	3.9863	0.3312
5	4.9878	0.3488	4.9862	0.3705	4.9846	0.3923	4.9828	0.4140
6	5.9854	0.4185	5.9835	0.4446	5.9815	0.4707	5.9794	0.4968
7	6.9829	0.4883	6.9807	0.5187	6.9784	0.5492	6.9759	0.5796
8	7.9805	0.5580	7.9780	0.5928	7.9753	0.6277	7.9725	0.6625
9	8.9780	0.6278	8.9752	0.6670	8.9722	0.7061	8.9691	0.7453
	5°	85°	5¼	84¾	5½	84½	5¾	84¼
1	0.9961	0.0871	0.9958	0.0915	0.9954	0.0958	0.9949	0.1002
2	1.9923	0.1743	1.9916	0.1830	1.9908	0.1917	1.9899	0.2004
3	2.9884	0.2615	2.9874	0.2745	2.9862	0.2875	2.9849	0.3006
4	3.9846	0.3486	3.9832	0.3660	3.9816	0.3834	3.9799	0.4008
5	4.9808	0.4358	4.9790	0.4575	4.9770	0.4792	4.9748	0.5009
6	5.9769	0.5229	5.9748	0.5490	5.9724	0.5751	5.9698	0.6011
7	6.9731	0.6101	6.9706	0.6405	6.9678	0.6709	6.9648	0.7013
8	7.9692	0.6972	7.9664	0.7320	7.9632	0.7668	7.9597	0.8015
9	8.9654	0.7844	8.9622	0.8235	8.9586	0.8626	8.9547	0.9017
	6°	84	6¼	83¾	6½	83½	6¾	83¼
1	0.9945	0.1045	0.9940	0.1088	0.9935	0.1132	0.9930	0.1175
2	1.9890	0.2090	1.9881	0.2177	1.9871	0.2264	1.9861	0.2351
3	2.9836	0.3136	2.9821	0.3266	2.9807	0.3396	2.9792	0.3526
4	3.9781	0 4181	3.9762	0.4355	3.9743	0.4528	3.9723	0.4701
5	4.9726	0.5226	4.9703	0.5443	4.9678	0.5660	4.9653	0.5877
6	5.9671	0.6272	5.9643	0.6532	5.9614	0.6792	5.9584	0.7052
7	6.9616	0.7317	6.9584	0.7621	6.9550	0.7924	6.9515	0.8228
8	7.9562	0.8362	7.9524	0.8709	7.9486	0.9056	7.9445	0.9403
9	8.9507	0.9408	8.9465	0.9798	8.9421	1.0188	8.9376	1.0578
	7°	83°	7¼	82¾	7½	82½	7¾	82¼
1	0.9925	0.1218	0.9920	0.1262	0.9914	0.1305	0.9908	0.1348
2	1.9851	0.2437	1.9840	0.2524	1.9829	0.2610	1.9817	0.2697
3	2.9776	0.3656	2.9760	0.3786	2.9743	0.3916	2.9726	0.4045
4	3.9702	0.4874	3.9680	0.5048	3.9657	0.5221	3.9635	0.5394
5	4.9627	0.6093	4.9600	0.6310	4.9572	0.6526	4.9543	0.6742
6	5.9553	0.7312	5.9520	0.7572	5.9487	0.7831	5.9452	0.8091
7	6.9478	0.8531	6.9440	0.8834	6.9401	0.9137	6.9361	0.9439
8	7.9404	0.9750	7.9360	1.0096	7.9315	1.0442	7.9269	1.0788
9	8.9329	1.0968	8.9280	1.1358	8.9230	1.1747	8.9178	1.2136
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	8°	82	8¼	81¾	8½	81½	8¾	81¼
1	0.9902	0.1391	0.9896	0.1435	0.9890	0.1478	0.9883	0.1521
2	1.9805	0.2783	1.9793	0.2870	1.9780	0.2956	1.9767	0.3042
3	2.9708	0.4175	2.9689	0.4305	2.9670	0.4434	2.9651	0.4564
4	3.9611	0.5567	3.9586	0.5740	3.9560	0.5912	3.9534	0.6085
5	4.9513	0.6959	4.9483	0.7175	4.9451	0.7390	4.9418	0.7606
6	5.9416	0.8350	5.9379	0.8605	5.9341	0.8868	5.9302	0.9127
7	6.9319	0.9742	6.9276	1.0045	6.9231	1.0347	6.9185	1.0649
8	7.9221	1.1134	7.9172	1.1479	7.9121	1.1825	7.9069	1.2170
9	8.9124	1.2526	8.9069	1.2914	8.9011	1.3303	8.8952	1.3691
	9°	81	9¼	80¾	9½	80½	9¾	80¼
1	0.9877	0.1564	0.9870	0.1607	0.9863	0.1650	0.9855	0.1693
2	1.9754	0.3129	1.9740	0.3215	1.9726	0.3301	1.9711	0.3387
3	2.9631	0.4693	2.9610	0.4822	2.9589	0.4951	2.9566	0.5080
4	3.9508	0.6257	3.9480	0.6430	3.9451	0.6602	3.9422	0.6774
5	4.9384	0.7822	4.9350	0.8037	4.9314	0.8252	4.9278	0.8467
6	5.9261	0.9386	5.9220	0.9644	5.9177	0.9903	5.9133	1.0161
7	6.9138	1.0950	6.9090	1.1252	6.9040	1.1553	6.8989	1.1854
8	7.9015	1.2515	7.8960	1.2859	7.8903	1.3204	7.8844	1.3548
9	8.8892	1.4079	8.8830	1.4467	8.8766	1.4854	8.8700	1.5241
	10°	80°	10¼	79¾	10½	79½	10¾	79¼
1	0.9848	0.1736	0.9840	0.1779	1.9832	0.1822	0.9824	0.1865
2	1.9696	0.3473	1.9681	0.3559	0.9665	0.3645	1.9649	0.3730
3	2.9544	0.5209	2.9521	0.5338	2.9497	0.5467	2.9473	0.5595
4	3.9392	0.6946	3.9362	0.7118	3.9330	0.7289	3.9298	0.7460
5	4.9240	0.8682	4.9202	0.8897	4.9163	0.9112	4.9123	0.9325
6	5.9088	1.0419	5.9042	1.0676	5.8995	1.0933	5.8947	1.1190
7	6.8937	1.2155	6.8883	1.2456	6.8828	1.2756	6.8772	1.3055
8	7.8785	1.3892	7.8723	1.4235	7.8660	1.4579	7.8596	1.4920
9	8.8633	1.5628	8.8564	1.6015	8.8493	1.6401	8.8421	1.6785
	11°	79	11¼	78¾	11½	78½	11¾	78¼
1	0.9816	0.1908	0.9808	0.1951	0.9799	0.1993	0.9790	0.2036
2	1.9633	0.3816	1.9616	0.3902	1.9598	0.3987	1.9581	0.4073
3	2.9449	0.5724	2.9424	0.5853	2.9398	0.5981	2.9371	0.6109
4	3.9265	0.7632	3.9231	0.7804	3.9197	0.7975	3.9162	0.8145
5	4.9081	0.9540	4.9039	0.9755	4.8996	0.9968	4.8952	1.0182
6	5.8898	1.1449	5.8847	1.1705	5.8796	1.1962	5.8743	1.2218
7	6.8714	1.3357	6.8655	1.3656	6.8595	1.3956	6.8533	1.4255
8	7.8533	1.5265	7.8463	1.5607	7.8394	1.5949	7.8324	1.6291
9	8.8346	1.7173	8.8271	1.7558	8.8193	1.7943	8.8114	1.8327
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	12°	78°	12¼	77¾	12½	77½	12¾	77¼
1	0.9781	0.2079	0.9772	0.2122	0.9763	0.2164	0.9753	0.2207
2	1.9563	0.4158	1.9544	0.4242	1.9526	0.4329	1.9507	0.4414
3	2.9344	0.6237	2.9317	0.6365	2.9289	0.6493	2.9260	0.6621
4	3.9126	0.8316	3.9089	0.8487	3.9052	0.8657	3.9014	0.8828
5	4.8907	1.0396	4.8861	1.0609	4.8815	1.0822	4.8767	1.1035
6	5.8689	1.2475	5.8634	1.2730	5.8578	1.2986	5.8520	1.3242
7	6.8470	1.4554	6.8406	1.4852	6.8341	1.5151	6.8274	1.5449
8	7.8252	1.6633	7.8178	1.6974	7.8104	1.7315	7.8027	1.7656
9	8.8033	1.8712	8.7951	1.9096	8.7867	1.9479	8.7781	1.9863
	13°	77°	13¼	76¾	13½	76½	13¾	76¼
1	0.9744	0.2249	0.9734	0.2292	0.9724	0.2334	0.9713	0.2377
2	1.9487	0.4499	1.9467	0.4584	1.9447	0.4669	1.9427	0.4754
3	2.9231	0.6749	2.9201	0.6876	2.9171	0.7003	2.9140	0.7131
4	3.8975	0.8998	3.8934	0.9168	3.8895	0.9338	3.8854	0.9507
5	4.8718	1.1248	4.8669	1.1460	4.8619	1.1672	4.8567	1.1884
6	5.8462	1.3497	5.8403	1.3752	5.8343	1.4007	5.8280	1.4261
7	6.8206	1.5746	6.8136	1.6044	6.8067	1.6341	6.7994	1.6638
8	7.7950	1.7996	7.7870	1.8336	7.7790	1.8676	7.7707	1.9015
9	8.7693	2.0246	8.7604	2.0628	8.7515	2.1010	8.7421	2.1392
	14°	76°	14¼	75¾	14½	75½	14¾	75¼
1	0.9703	0.2419	0.9692	0.2461	0.9681	0.2504	0.9670	0.2546
2	1.9406	0.4838	1.9385	0.4923	1.9363	0.5008	1.9341	0.5092
3	2.9109	0.7258	2.9077	0.7385	2.9044	0.7511	2.9011	0.7638
4	3.8812	0.9677	3.8769	0.9846	3.8727	1.0015	3.8682	1.1084
5	4.8515	1.2096	4.8461	1.2308	4.8407	1.2519	4.8352	1.2730
6	5.8218	1.4515	5.8154	1.4769	5.8089	1.5023	5.8023	1.5276
7	6.7921	1.6935	6.7846	1.7231	6.7770	1.7527	6.7693	1.7822
8	7.7624	1.9354	7.7538	1.9692	7.7452	2.0030	7.7364	2.0368
9	8.7327	2.1773	8.7231	2.2154	8.7133	2.2534	8.7034	2.2914
	15	75	15¼	74¾	15½	74½	15¾	74¼
1	0.9659	0.2588	0.9648	0.2630	0.9636	0.2672	0.9624	0.2714
2	1.9319	0.5176	1.9296	0.5261	1.9273	0.5345	1.9249	0.5429
3	2.8978	0.7765	2.8944	0.7891	2.8909	0.8017	2.8874	0.8143
4	3.8637	1.0353	3.8591	1.0521	3.8545	1.0689	3.8498	1.0858
5	4.8296	1.2941	4.8239	1.3152	4.8182	1.3362	4.8123	1.3572
6	5.7956	1.5529	5.7887	1.5782	5.7818	1.6034	5.7747	1.6286
7	6.7615	1.8117	6.7535	1.8412	6.7454	1.8707	6.7372	1.9001
8	7.7274	2.0706	7.7183	2.1042	7.7090	2.1379	7.6996	2.1715
9	8.6933	2.3294	8.6831	2.3673	8.6727	2.4051	8.6621	2 4430
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	16°	74	16¼	73¾	16½	73½	16¾	73¼
1	0.9612	0.2756	0.9600	0.2798	0.9588	0.2840	0.9575	0.2882
2	1.9225	0.5513	1.9201	0.5596	1.9176	0.5680	1.9151	0.5764
3	2.8838	0.8269	2.8801	0.8395	2.8765	0.8520	2.8727	0.8646
4	3.8450	1.1025	3.8402	1.1193	3.8353	1.1361	3.8303	1.1528
5	4.8063	1.3782	4.8002	1.3991	4.7941	1.4201	4.7878	1.4410
6	5.7676	1.6538	5.7603	1.6790	5.7529	1.7041	5.7454	1.7292
7	6.7288	1.9295	6.7203	1.9588	6.7117	1.9881	6.7030	2.0174
8	7.6901	2.2051	7.6804	2.2386	7.6705	2.2721	7.6606	2.3056
9	8.6513	2.4807	8.6404	2.5185	8.6294	2.5561	8.6181	2.5938
	17	73	17¼	72¾	17½	72½	17¾	72¼
1	0.9563	0.2924	0.9550	0.2965	0.9537	0.3007	0.9523	0.3048
2	1.9126	0.5847	1.9100	0.5931	1.9074	0.6014	1.9048	0.6097
3	2.8689	0.8771	2.8651	0.8896	2.8611	0.9021	2.8572	0.9146
4	3.8252	1.1695	3.8201	1.1862	3.8149	1.2028	3.8096	1.2195
5	4.7815	1.4619	4.7751	1.4827	4.7686	1.5035	4.7620	1.5243
6	5.7378	1.7542	5.7301	1.7792	5.7223	1.8042	5.7144	1.8292
7	6.6941	2.0466	6.6851	2.0758	6.6760	2.1049	6.6668	2.1340
8	7.6504	2.3390	7.6402	2.3723	7.6297	2.4056	7.6192	2.4389
9	8.6067	2.6313	8.5952	2.6689	8.5834	2.7063	8.5716	2.7438
	18°	72	18¼	71¾	18½	71½	18¾	71¼
1	0.9510	0.3090	0.9497	0.3131	0.9483	0.3173	0.9469	0.3214
2	1.9021	0.6180	1.8994	0.6263	1.8966	0.6346	1.8939	0.6429
3	2.8532	0.9271	2.8491	0.9395	2.8450	0.9519	2.8408	0.9643
4	3.8042	1.2361	3.7988	1.2527	3.7933	1.2692	3.7877	1.2857
5	4.7553	1:5451	4.7485	1.5658	4.7416	1.5865	4.7346	1.6072
6	5.7063	1.8541	5.6982	1.8790	5.6899	1.9038	5.6816	1.9286
7	6.6574	2.1631	6.6479	2.1921	6.6383	2.2211	6.6285	2.2501
8	7.6084	2.4721	7.5976	2.5053	7.5866	2.5384	7.5754	2.5715
9	8.5595	2.7812	8.5473	2.8185	8.5349	2.8557	8.5224	2.8929
	19°	71°	19¼	70¾	19½	70½	19¾	70¼
1	0.9455	0.3255	0.9441	0.3297	0.9426	0.3338	0.9412	0.3379
2	1.8910	0.6511	1.8882	0.6594	1.8853	0.6676	1.8823	0.6758
3	2.8366	0.9767	2.8323	0.9891	2.8279	1.0014	2.8233	1.0137
4	3.7821	1.3023	3.7764	1.3188	3.7706	1.3352	3.7647	1.3517
5	4.7276	1 6278	4.7204	1.6484	4.7132	1.6690	4.7059	1.6896
6	5.6731	1.9534	5.6645	1.9781	5.6558	2.0028	5.6471	2.0275
7	6.6186	2.2790	6.6086	2.3078	6.5985	2.3366	6.5882	2.3654
8	7.5641	2.6045	7.5527	2.6375	7.5411	2.6705	7.5294	2.7033
9	8.5097	2.9301	8.4968	2.9672	8.4838	3.0043	8.4706	3.0412
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	20	70	20¼	69¾	20½	69½	20¾	69¼
1	0.9397	0.3420	0.9382	0.3461	0.9366	0.3502	0.9351	0.3543
2	1.8794	0.6840	1.8764	0.6922	1.8733	0.7004	1.8703	0.7086
3	2.8191	1.0261	2.8146	1.0383	2.8100	1.0506	2.8054	1.0629
4	3.7588	1.3681	3.7528	1.3845	3.7467	1.4008	3.7405	1.4172
5	4.6985	1.7101	4.6910	1.7306	4.6834	1.7510	4.6757	1.7715
6	5.6381	2.0521	5.6291	2.0767	5.6200	2.1012	5.6108	2.1257
7	6.5778	2.3941	6.5673	2.4228	6.5567	2.4514	6.5459	2.4800
8	7.5175	2.7362	7.5055	2.7689	7.4934	2.8016	7.4811	2.8343
9	8.4572	3.0782	8.4437	3.1150	8.4300	3.1519	8.4162	3.1886
	21°	69°	21¼	68¾	21½	68½	21¾	68¼
1	0.9336	0.3584	0.9320	0.3624	0.9304	0.3665	0.9288	0.3705
2	1.8672	0.7167	1.8640	0.7249	1.8608	0.7330	1.8576	0.7411
3	2.8008	1.0751	2.7960	1.0873	2.7913	1.0995	2.7864	1.1117
4	3.7343	1.4335	3.7280	1.4497	3.7217	1.4660	3.7152	1.4822
5	4.6679	1.7918	4.6600	1.8122	4.6521	1.8325	4.6440	1.8528
6	5.6015	2.1502	5.5920	2.1746	5.5825	2.1990	5.5729	2.2233
7	6.5351	2.5086	6.5240	2.5371	6.5129	2.5655	6.5017	2.5939
8	7.4686	2.8669	7.4560	2.8995	7.4433	2.9320	7.4305	2.9644
9	8.4022	3.2253	8.3880	3.2619	8.3738	3.2985	8.3593	3.3350
	22°	68°	22¼	67¾	22½	67½	22¾	67¼
1	0.9272	0.3746	0.9255	0.3786	0.9239	0.3827	0.9222	0.3867
2	1.8544	0.7492	1.8511	0.7573	1.8478	0.7654	1.8444	0.7734
3	2.7816	1.1238	2.7766	1.1359	2.7716	1.1480	2.7666	1.1601
4	3.7087	1.4984	3.7022	1.5146	3.6956	1.5307	3.6888	1.5468
5	4.6359	1.8730	4.6277	1.8932	4.6194	1.9134	4.6110	1.9335
6	5.5631	2.2476	5.5532	2.2719	5.5433	2.2961	5.5332	2.3202
7	6.4903	2.6222	6.4788	2.6505	6.4671	2.6788	6.4554	2.7069
8	7.4175	2.9968	7.4043	3.0292	7.3910	3.0615	7.3776	3.0936
9	8.3447	3.3715	8.3299	3.4078	8.3149	3.4441	8.2998	3.4803
	23	67	23¼	66¾	23½	66½	23¾	66¼
1	0.9205	0.3907	0.9188	0.3947	0.9170	0.3987	0.9153	0.4027
2	1.8410	0.7815	1.8376	0.7895	1.8341	0.7975	1.8306	0.8055
3	2.7615	1.1722	2.7564	1.1842	2.7512	1.1962	2.7459	1.2082
4	3.6820	1.5629	3.6752	1.5790	3.6682	1.5950	3.6612	1.6110
5	4.6025	1.9537	4.5939	1.9737	4.5853	1.9937	4.5766	0.0137
6	5.5230	2.3444	5.5127	2.3685	5.5024	2.3925	5.4919	2.4165
7	6.4435	2.7351	6.4315	2.7632	6.4194	2.7912	6.4072	2.8192
8	7.3640	3.1258	7.3503	3.1579	7.3365	3.1900	7.2225	3.2220
9	8.2845	3.5166	8.2691	3.5527	8.2535	3.5887	8.2378	3.6247
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	24	66	24¼	65¾	24½	65½	24¾	65¼
1	0.9135	0.4067	0.9117	0.4107	0.9099	0.4147	0.9081	0.4186
2	1.8271	0.8135	1.8235	0.8214	1.8199	0.8294	1.8163	0.8373
3	2.7406	1,2202	2.7353	1.2322	2.7299	1.2441	2.7244	1.2560
4	3.6542	1.6269	3.6470	1.6429	3.6398	1.6588	3.6326	1.6746
5	4.5677	2.0337	4.5588	2.0536	4.5498	2.0735	4.5407	2.0933
6	5.4813	2.4404	5.4706	2.4643	5.4598	2.4882	5.4489	2.5122
7	6.3948	2.8472	6.3823	2.8750	6.3697	2.9029	6.3570	2.9306
8	7.3084	3.2539	7.2941	3.2857	7.2797	3.3175	7.2651	3.3493
9	8.2219	3.6606	8.2058	3.6965	8.1896	3.7322	8.1733	3.7679
	25°	65	25¼	64¾	25½	64½	25¾	64¼
1	0.9063	0.4226	0.9044	0.4265	0.9026	0.4305	0.9007	0.4344
2	1.8126	0.8452	1.8089	0.8531	1.8052	0.8610	1.8014	0.8688
3	2.7189	1.2679	2.7134	1.2797	2.7077	1 2915	2.7021	1.3032
4	3.6252	1.6905	3.6178	1.7063	3.6103	1.7220	3.6028	1.7376
5	4.5315	2.1131	4.5223	2.1328	4.5129	2.1525	4.5035	2.1720
6	5.4378	2.5357	5.4267	2.5594	5.4155	2.5831	5.4042	2.6064
7	6 3442	2.9583	6.3312	2.9860	6.3181	3.0136	6.3049	3.0408
8	7.2505	3.3809	7.2356	3.4125	7.2207	3.4441	7.2056	3.4752
9	8.1568	3.8036	8.1401	3.8391	8.1233	3.8746	8.1063	3.9096
	26°	64°	26¼	63¾	26½	63½	26¾	63¼
1	0.8988	0.4384	0.8969	0.4423	0.8949	0.4462	0.8930	0.4501
2	1.7976	0.8767	1.7937	0.8846	1.7899	0.8924	1.7859	0.9002
3	2.6964	1.3151	2.6906	1.3269	2.6848	1.3386	2.6789	1.3503
4	3.5952	1.7535	3.5875	1.7692	3.5797	1.7848	3.5719	1.8004
5	4.4940	2.1919	4.4843	2.2115	4.4746	2.2310	4.4649	2.2505
6	5.3928	2.6302	5.3812	2.6537	5.3696	2.6772	5.3579	2.7006
7	6.2916	3.0686	6.2781	3.0966	6.2645	3.1234	6.2508	3.1507
8	7.1904	3.5070	7.1750	3.5383	7.1594	3.5696	7.1438	3.6008
9	8.0891	3.9453	8.0718	3.9806	8.0544	4.0158	8.0368	4.0509
	27°	63	27¼	62¾	27½	62½	27¾	62¼
1	0.8910	0.4540	0.8890	0.4578	0.8870	0.4617	0.8850	0.4656
2	1.7820	0.9080	1.7780	0.9157	1.7740	0.9235	1.7700	0.9312
3	2.6730	1.3620	2.6670	1.3736	2.6610	1.3852	2.6550	1.3968
4	3.5640	1.8160	3.5561	1.8315	3.5480	1.8470	3.5400	1.8624
5	4.4550	2.2699	4.4451	2.2894	4.4350	2.3087	4.4250	2.3281
6	5 3460	2.7239	5.3341	2.7472	5.3221	2.7705	5.3099	2.7937
7	6.2370	3.1779	6.2231	3.2051	6.2092	3.2322	6.1949	3.2593
8	7.1280	3.6319	7.1121	3.6630	7.0961	3.6940	7.0799	3.7249
9	8.0191	4.0859	8.0011	4.1209	7.9831	4.1553	7.9649	4.1905
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	28	62	28¼	61¾	28½	61½	28¾	61¼
1	0.8829	0.4694	0.8809	0.4733	0.8788	0.4771	0.8766	0.4810
2	1.7659	0.9389	1.7618	0.9466	1.7576	0.9543	1.7534	0.9620
3	2.6488	1.4084	2.6427	1.4199	2.6364	1.4315	2.6302	1.4430
4	3.5318	1.8779	3.5236	1.8933	3.5153	1.9086	3.5069	1.9239
5	4.4147	2.3474	4.4045	3.3666	4.3941	2.3858	4.3836	2.4049
6	5.2977	2.8168	5.2854	2.8399	5.2729	2.8629	5.2604	2.8859
7	6.1806	3.2863	6.1662	3.3132	6.1517	3.3401	6.1371	3.3669
8	7.0636	3.7558	7.0471	3.7866	7.0305	3.8173	7.0138	3.8479
9	7.9465	4.2252	7.9280	4.2599	7.9093	4.2944	7.8905	4.3289
	29	61	29¼	60¾	29½	60½	29¾	60¼
1	0.8746	0.4848	0.8725	0.4886	0.8703	0.4924	0.8682	0.4962
2	1.7492	0.9696	1.7450	0.9772	1.7407	0.9848	1.7364	0.9924
3	2.6239	1.4544	2.6175	1.4659	2.6111	1.4773	2.6046	1.4886
4	3.4985	1.9392	3.4900	1.9545	3.4814	1.9697	3.4728	1 9849
5	4.3731	2.4240	4.3625	2.4431	4.3518	2.4621	4.3410	2.4811
6	5.2477	2.9089	5.2350	2.9317	5.2221	2.9545	5.2092	2.9773
7	6.1223	3.3937	6.1075	3.4203	6.0925	3.4463	6.0774	3.4735
8	6.9970	3.8785	6.9800	3.9090	6.9628	3.9394	7.9456	3.9697
9	7.8716	4.3633	7.8525	4.3976	7.8332	4.4318	7.8138	4.4659
	30	60	30¼	59¾	30½	59½	30¾	59¼
1	0.8660	0.5000	0.8638	0.5038	0.8616	0.5075	0.8594	0.5113
2	1.7320	1.0000	1.7277	1.0076	1.7232	1.0151	1.7188	1.0226
3	2.5981	1.5000	2.5915	1.5113	2.5849	1.5226	2.5782	1.5339
4	3.4641	2.2000	3.4552	2.0151	3.4465	2.0301	3.4376	2.0452
5	4.3301	2.5000	4.3192	2.5189	4.3081	2.5377	4.2970	2.5564
6	5.1961	3.3000	5.1830	3.0226	5.1698	3.0452	5.1564	3.0677
7	6.0622	3.5000	6.0468	3.5264	6.0314	3.5528	6.0158	3.5790
8	6.9282	4.0000	6.9107	4.0302	6.8930	4.0603	6.8752	4.0903
9	7.7942	4.5000	7.7745	4.5339	7.7547	4.5678	7.7346	4.6016
	31	59	31¼	58¾	31½	58½	31¾	58¼
1	0.8571	0.5150	0.8549	0.5188	0.8526	0.5225	0.8503	0.5262
2	1.7143	1.0301	1.7098	1.0375	1.7053	1.0450	1.7007	1.0524
3	2.5715	1 5451	2.5647	1.5563	2.5579	1.5675	2.5510	1.5786
4	3.4287	2.0602	3.4196	2.0751	3.4106	2.0900	3.4014	2.1048
5	4.2858	2.5752	4.2745	2.5939	4.2632	2.6125	4.2518	2.6311
6	5.1430	3.0902	5.1295	3.1126	5.1158	3.1350	5.1021	3.1573
7	6 0002	3.6053	5.9844	3.6314	5.9685	3.6575	5.9525	3.6835
8	6.8573	4.1203	6.8393	4.1502	6.8211	4.1800	6.8028	4.2097
9	7.7145	4.6353	7.6942	4.6689	7.6738	4.7025	7.6532	4.7359
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	32°	58°	32¼	57¾	32½	57½	32¾	57¼
1	0.8480	0.5299	0.8457	0.5336	0.8434	0.5373	0.8410	0.5409
2	1.6961	1.0598	1.6914	1.0672	1.6868	1.0746	1.6821	1.0819
3	2.5441	1.5897	2.5372	1.6008	2.5302	1.6119	2.5231	1.6229
4	3.3922	2.1197	3.3829	2.1344	3.3736	2.1492	3.3642	2.1639
5	4.2402	2.6496	4.2286	2.6681	4.2169	2.6865	4.2052	2.7049
6	5.0883	3.1795	5.0744	3.2017	5.0603	3.2238	5.0462	3.2458
7	5.9363	3.7094	5.9201	3.7353	5.9037	3.7611	5.8873	3.7868
8	6.7844	4.2394	6.7658	4.2689	6.7471	4.2984	6.7283	4.3278
9	7.6324	4.7693	7.6115	4.8025	7.5905	4.8357	7.5694	4.8688
	33	57	33¼	56¾	33½	56½	33¾	56¼
1	0.8386	0.5446	0.8363	0.5483	0.8339	0.5519	0.8314	0.5555
2	1.6773	1.0893	1.6726	1.0966	1.6678	1.1039	1.6629	1.1111
3	2.5160	1.6339	2.5089	1.6449	2.5017	1.6558	2.4944	1.6667
4	3.3547	2.1786	3.3451	2.1932	3.3355	2.2077	3.3259	2.2223
5	4.1934	2.7232	4.1814	2.7415	4.1694	2.7597	4.1573	2.7778
6	5.0320	3.2678	5.0177	3.2898	5.0033	3.3116	4.9888	3.3334
7	5.8707	3.8125	5.8540	3.8381	5.8372	3.8635	5.8203	3.8890
8	6.7094	4.3571	6.6903	4.3863	6.6711	4.4155	6.6518	4.4446
9	7.5480	4.9018	7.5266	4.9346	7.5059	4.9674	7.4832	5.0001
	34	56°	34¼	55¾	34½	55½	34¾	55¼
1	0.8290	0.5592	0.8266	0.5628	0.8241	0.5664	0.8216	0.5700
2	1.6581	1.1184	1.6532	1.1256	1.6482	1.1328	1.6433	1.1400
3	2.4871	1.6776	2.4798	1.6884	2.4724	1.6992	2.4649	1.7100
4	3.3162	2.2368	3.3063	2.2512	3.2965	2.2656	3.2866	2.2800
5	4.1452	2.7960	4.1329	2.8140	4.1206	2.8320	4.1082	2.8500
6	4.0742	3.3552	4.9595	3.3768	4.9447	3.3984	4.9299	3.4200
7	5.8033	3.9144	5.7861	3.9396	5.7689	3.9648	5.7515	3.9900
8	6.6323	4.4735	6.6127	4.5024	6.5930	4.5313	6.5732	4.5600
9	7.4613	5.0327	7.4393	5.0652	7.4171	5.0977	7.3948	5.1300
	35°	55	35¼	54¾	35½	54½	35¾	54¼
1	0.8191	0.5736	0.8166	0.5771	0.8141	0.5807	0.8116	0.5842
2	1.6383	1.1472	1.6333	1.1543	1.6282	1.1614	1.6231	1.1685
3	2.4575	1.7207	2.4499	1.7314	2.4423	1.7421	2.4347	1.7527
4	3.2766	2.2943	3.2666	2.3086	3.2565	2.3228	3.2463	2.3370
5	4.0958	2.8679	4.0832	2.8857	4.0706	2.9035	4.0579	2.9212
6	4.9149	3.4415	4.8998	3.4629	4.8847	3.4842	4.8694	3.5055
7	5.7341	4.0150	5.7165	4.0400	5.6988	4.0649	5.6810	4.0897
8	6.5532	4.5886	6.5331	4.6172	6.5129	4.6456	6.4926	4.6740
9	7.3724	5.1622	7.3498	5.1943	7.3270	5.2263	7.3042	5.2582
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	36	54	36¼	53¾	36½	53½	36¾	53¼
1	0.8090	0.5878	0.8064	0.5913	0.8038	0.5948	0 8012	0.5983
2	1.6181	1.1756	1.6129	1.1826	1.6077	1.1896	1.6025	1.1966
3	2.4271	1.7634	2.4193	1.7739	2.4116	1.7845	2.4038	1.7950
4	3.2361	2.3511	3.2258	2.3652	3.2154	2.3793	3.2050	2.3933
5	4.0451	2.9389	4.0322	2.9565	4.0193	2.9741	4.0063	2.9916
6	4.8541	3.5267	4.8387	3.5478	4.8231	3.5689	4.8075	3.5899
7	5.6631	4.1145	5.6451	4.1391	5.6270	4.1638	5.6088	4.1883
8	6.4721	4.7023	6.4516	4.7304	6.4308	4.7586	6.4100	4.7866
9	7.2812	5.2901	7.2580	5.3217	7.2347	5.3534	7.2111	5.3849
	37	53	37¼	52¾	37½	52½	37¾	52¼
1	0.7986	0.6018	0.7960	0.6053	0.7933	0.6087	0.7907	0.6122
2	1.5973	1.2036	1.5920	1.2106	1.5867	1 2175	1.5814	1.2244
3	2.3959	1.8054	2.3880	1.8159	2.3801	1.8263	2.3721	1.8366
4	3.1945	2.4073	3.1840	2.4212	3.1734	2.4350	3.1628	2.4489
5	3.9932	3.0091	3.9800	3.0265	3.9668	3.0438	3.9534	3.0611
6	4.7918	3.6109	4.7760	3.6318	4.7601	3.6526	4.7441	3.6733
7	5.5904	4.2127	5.5720	4.2371	5.5535	4.2613	5.5348	4.2855
8	6 3891	4.8145	6.3680	4.8424	6.3468	4.8701	6.3255	4.8977
9	7.1877	5.4163	7.1640	5.4476	7.1402	5.4788	7.1162	5.5099
	38°	52	38¼	51¾	38½	51½	38¾	51¼
1	0.7880	0.6156	0.7853	0.6191	0.7826	0.6225	0.7799	0.6259
2	1.5760	1.2313	1.5706	1.2382	1.5652	1.2450	1.5598	1.2518
3	2.3640	1.8470	2.3559	1.8573	2.3478	1.8675	2.3397	1.8778
4	3.1520	2.4626	3.1413	2.4764	3.1304	2.4900	3.1195	2.5037
5	3.9401	3.0783	3.9266	3.0955	3.9130	3.1125	3.8994	3.1296
6	4.7281	3.6940	4.7119	3.7146	4.6956	3.7351	4.6793	3.7555
7	5.5161	4.3096	5.4972	4.3337	5.4782	4.3576	5.4592	4.3815
8	6.3041	4.9253	6.2825	4.9528	6.2608	4.9801	6.2391	5.0074
9	7.0921	6.5409	7.0678	5.5718	7.0434	5.6026	7.0190	5.6333
	39°	51	39¼	50¾	39½	50½	39¾	50¼
1	0.7771	0.6293	0.7744	0.6327	0.7716	0.6361	0.7688	0.6394
2	1.5543	1.2586	1.5488	1.2654	1.5432	1.2621	1.5377	1.2789
3	2.3314	1.8880	2.3232	1.8981	2.3149	1.9082	2.3065	1.9183
4	3.1086	2.5173	3.0976	2.5308	3.0865	2.5443	3.0754	2.5578
5	3.8857	3.1466	3.8719	3.1635	3.8581	3.1804	3.8442	3.1972
6	4.6629	3.7759	4.6463	3.7962	4.6297	3.8165	4.6130	3.8366
7	5 4400	4.4052	5.4207	4.4289	5.4014	4.4525	5.3819	4.4761
8	6.2172	5.0346	6.1951	5.0616	6.1730	5.0886	6.1507	5.1155
9	6.9943	5.6639	6.9695	5.6943	6.9446	5.7247	6.9196	5.7550
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	40°	50	40¼	49¾	40½	49½	40¾	49¼
1	0.7660	0.6428	0.7632	0.6461	0.7604	0.6494	0.7575	0.6527
2	1.5321	1.2856	1.5265	1.2922	1.5208	1.2989	1.5151	1.3055
3	2.2981	1.9284	2.2897	1.9384	2.2812	1.9483	2.2727	1.9583
4	3.0642	2.5711	3.0529	2.5845	3.0416	2.5978	3.0303	2.6110
5	3.8302	3.2139	3.8162	3.2306	3.8020	3.2472	3.7878	3.2638
6	4.5963	3.8567	4.5794	3.8767	4.5624	3.8967	4.5454	3.9166
7	5.3623	4.4995	5.3425	4.5229	5.3228	4.5461	5.3029	4.5693
8	6.1284	5.1423	6.1059	5.1690	6.0832	5.1956	6.0605	5.2221
9	6.8944	5.7851	6.8691	5.8151	6.8436	5.8450	6.8181	5.8748
	41	49	41¼	48¾	41½	48½	41¾	48¼
1	0.7547	0.6560	0.7518	0.6593	0.7489	0.6626	0.7460	0.6659
2	1.5094	1.3121	1.5037	1.3187	1.4979	1.3252	1.4921	1.3318
3	2.2641	1.9682	2.2555	1.9780	2.2468	1.9879	2.2382	1.9976
4	3.0188	2.6242	3.0074	2.6374	2.9958	2.6505	2.9842	2.6635
5	3.7735	3.2803	3.7592	3.2967	3.7447	3.3131	3.7303	3.3294
6	4.5283	3.9364	4.5110	3.9560	4.4937	3.9757	4.4764	3.9953
7	5.2830	4.5924	5.2629	4.6154	5.2426	4.6383	5.2224	4.6612
8	6.0377	5.2485	6.0147	5.2747	5.9916	5.3010	5.9685	5.3270
9	6.7924	5.9045	6.7666	5.9341	6.7405	5.9636	6.7145	5.9929
	42	48	42¼	47¾	42½	47½	42¾	47¼
1	0.7431	0.6691	0.7402	0.6723	0.7373	0.6756	0.7343	0.6788
2	1.4863	1.3383	1.4804	1.3147	1.4746	1.3512	1.4686	1.3576
3	2.2294	2.0074	2.2207	2.0171	2.2118	2.0268	2.2029	2.0364
4	2.9726	2.6765	2.9609	2.6895	2.9491	2.7024	2.9373	2.7152
5	3.7157	3.3457	3.7011	3.3618	3.6864	3.3779	3.6716	3.3940
6	4.4589	4.0148	4.4413	4.0342	4.4237	4.0535	4.4059	4.0728
7	5.2020	4.6839	5.1815	4.7066	5.1610	4.7291	5.1402	4.7516
8	5.9452	5.3530	5.9218	5.3789	5.8982	5.4047	5.8746	5.4304
9	6.6883	6.0222	6.6620	6.0513	6.6355	6.0803	6.6089	6.1092
	43	47	43¼	46¾	43½	46½	43¾	46¼
1	0.7313	0.6820	0.7283	0.6852	0.7253	0.6883	0.7223	0.6915
2	1.4627	1.3640	1.4567	1.3704	1.4507	1.3767	1.4447	1.3830
3	2.1941	2.0460	2.1851	2.0555	2.1761	2.0651	2.1671	2.0745
4	2.9254	2.7280	2.9135	2.7407	2.9015	2.7534	2.8894	2.7660
5	3.6568	3.4100	3.6418	3.4259	3.6269	3.4418	3.6118	3.4576
6	4.3881	4.0920	4.3702	4.1111	4.3522	4.1301	4.3342	4.1491
7	5.1195	4.7740	5.0986	4.7963	5.0776	4.8185	5.0565	4.8406
8	5.8508	5.4560	5.8269	5.4814	5.8030	5.5068	5.7789	5.5321
9	6.5822	6.1380	6.5553	6.1666	6.5284	6.1952	6.5013	6.2236
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF LATITUDE AND DEPARTURE.

	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.
	44°	46	44$\frac{1}{4}$	45$\frac{3}{4}$	44$\frac{1}{2}$	45$\frac{1}{2}$	44$\frac{3}{4}$	45$\frac{1}{4}$
1	0.7193	0.6946	0.7163	0.6978	0.7132	0.7009	0.7102	0.7040
2	1.4387	1.3893	1.4326	1.3956	1.4265	1.4018	1.4204	1.4080
3	2.1580	2.0840	2.1489	2.0934	2.1397	2.1027	2.1305	2.1120
4	2.8774	2.7786	2.8652	2.7912	2.8530	2.8036	2.8407	2.8161
5	3.5967	3.4733	3.5815	3.4889	3.5662	3.5045	3.5509	3.5201
6	4.3160	4.1679	4.2978	4.1867	4.2795	4.2054	4.2611	4.2241
7	5.0354	4.8626	5.0141	4.8845	4.9927	4.9063	4.9713	4.9281
8	5.7547	5.5573	5.7304	5.5823	5.7060	5.6072	5.6815	5.6321
9	6.4741	6.2519	6.4467	6.2801	6.4192	6.3081	6.3917	6.3361
	45	45						
1	0.7071	0.7071						
2	1.4142	1.4142						
3	2.1213	2.1213						
4	2.8284	2.8284						
5	3.5355	3.5355						
6	4.2426	4.2426						
7	4.9497	4.9497						
8	5.6569	5.6569						
9	6.3640	6.3640						
	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.	E. W.	N. S.

TABLES OF SURVEYS.

THE USE OF THE FOREGOING TABLES IN RELATION TO SURVEYS.

THEY show, by inspection, the alteration of latitude and departure to every degree on the compass, and that for any distance not exceeding 100.000 links.

In the uppermost rank of every division are placed the several angles and their complements, to 45°, including the quarter, half, and three-quarters of degrees; and in the left-hand column are lengths of the measured lines of the field-work, and in the common areas are the difference of latitude and departure.

EXAMPLES.

Suppose the angle to be N. E. $27\frac{1}{2}$ degrees, and the line in the field measured to 6 chains, and it be required to find the Northings and Eastings of that station, under $27\frac{1}{2}$ degrees, and answering to 6 in left-hand column, the number in the com-

mon area, 5.3221, which shows the Northings; and under $62\frac{1}{2}$, (which is the complement to that angle) opposite the same number in the side column, I find 2.7705, which shows the Easting of that station. If the course be the same, and distance 60 chains, remove the decimal point one place to the right-hand, and the latitude and departure will be 53.221 27,705.

And if the line were 600 chains, the course remaining the same, the Northings would be 532 chains, 21 links, and the Eastings 277 chains, 05 links.

If the measured line doth not consist of an exact number of tens, as suppose its length to be 75 chains, 03 links, or 75 chains, 34 links, and the course $27\frac{1}{2}°$; then under this angle, and opposite

C.			
70 are	62.091	70 chains	32.322
5 "	4.435	5 "	2.308
0.30 links	0.266	0.30 links	0.138
0.04 "	0.035	0.04 "	0.018
Northing	66.827	Easting	34.786
for 75 chains, 34 links.		for 75 chains, 34 links.	

And so for any other.

N. B. These tables will answer to $\frac{1}{8}°$ or $7\frac{1}{2}'$, an arithmetical mean between $\frac{1}{4}°$ and $\frac{1}{2}°$, or between $\frac{1}{2}°$ and $\frac{3}{4}°$.

SYSTEMS OF RECTANGULAR SURVEYING FOR SURVEYING THE PUBLIC LANDS OF THE UNITED STATES.*

THE public lands of the United States are ordinarily surveyed into rectangular tracts, bounded by lines conforming to the cardinal points. This is effected by meridian lines and parallels of latitude, established six miles apart. The squares thus formed are called *townships.* They are bodies of land 6 miles square, as near as may be, containing as near as may be 23,040 acres. The townships are subdivided into 36 tracts, called *sections*, each containing as near as may be 640 acres. Any number or series of contiguous townships, situate north or south of each other, constitute a range.

* This section is mainly taken from "Manual of Surveying Instructions for the Survey of the Public Lands of the United Sates and Private Land Claims, Washington, 1890."

The law requires that the lines of the public surveys shall be governed by the true meridian, and that the townships shall be six miles square—two things involving in connection a mathematical impossibility—for, strictly to conform to the meridian, necessarily throws the township out of square by reason of the convergency of meridians, and hence, by adhering to the true meridian, results the necessity of departing from the strict requirements of law as respects the precise area of townships and the subdivisional parts thereof, the townships assuming something of a trapezoidal form, which inequality develops itself more and more as such, the higher the latitude of the surveys. In view of these circumstances the law provides that the sections of a mile square shall contain the quantity of 640 acres, *as nearly as may be*, and moreover provides that in all cases where the exterior lines of the townships, thus to be subdivided into sections or half sections, shall exceed or shall not extend 6 miles, the excess or deficiency shall be especially noted, and added to or deducted from the western or northern ranges of sections or half sections in such townships, according as the error may be in

running the lines from east to west, or from south to north; the sections and half sections bounded on the northern and western lines of such townships shall be sold as containing only the quantity expressed in the returns and plats, respectively, and all others as containing the complete legal quantity.

Standard parallels are established at intervals of every 24 miles, north and south of the base line, and guide meridians at intervals of every 24 miles, east and west of the principal meridian; the object being to confine the errors resulting from convergence of meridians and inaccuracies in measurements, within the tracts of lands bounded by the lines so established.

The survey of all principal base and meridian, standard parallels and guide meridians and township lines, must be made with an instrument operating independently of the magnetic needle. Burt's improved *solar compass*, or other instrument of equal utility, must be used of necessity in such cases; and it is deemed best that such instrument should be used under all circumstances. Where the needle can be relied on, however, the ordinary compass, if provided with a revolving

compass box and variation arc, may be used in subdividing and meandering.

The township lines and the subdivision lines will usually be measured by a two-pole chain of 33 feet in length, consisting of 50 links, and each link being seven and ninety-two-hundredths of an inch long. On uniform and level ground, however, the four-pole chain may be used. The measurements will, however, always be represented according to the four-pole chain of 100 links.

Tally-pins. Eleven tally-pins made of steel are to be used. They should not exceed 14 inches in length, be weighty enough toward the point to make them drop perpendicularly, and have a ring at the top, in which is to be fixed a piece of red cloth, or something else of conspicuous color to make them readily seen when stuck in the ground.

Process of chaining. In measuring lines with a two-pole chain, every *five* chains are called a "tally;" and in measuring lines with a four-pole chain every *ten* chains are called a tally, because at that distance the last of the ten tally-pins with which the forward chainman sets ont will have been stuck. He then cries "tally," which cry is

repeated by the other chainman, and each registers the distance by slipping a thimble, button or ring of leather, or something of the kind, on a belt worn for that purpose, or by some other convenient method. The hind chainman then comes up, and having counted, in the presence of his fellow, the tally-pins which he has taken up, so that both may be assured that none of the pins have been lost, he then takes the forward end of the chain and proceeds to set the pins. Thus the chainmen alternately change places, each setting the pins that he has taken up, so that one is forward in all the odd, and the other in all the even tallies. Such procedure, it is believed, tends to assure accuracy in measurement, facilitates the recollection of the distances to objects on the line, and renders a mis-tally almost impossible.

Levelling the chain and plumbing the pins. The length of every line run is to be ascertained by precise horizontal measurements, as nearly approximating to an air-line as is possible in practice on the earth's surface. This all-important object can only be attained by a rigid adherence to the three following observances:

1. Ever keeping the chain stretched to its utmost degree of tension on even ground.

2. On even ground, keeping the chain not only stretched as aforesaid, but horizontally levelled. And when ascending or descending steep ground, hills or mountains, the chain will have to be shortened to one-half its length (and sometimes more), in order accurately to obtain the true horizontal measure.

3. The careful plumbing of the tally pins, so as to ascertain precisely the spot where they should be stuck. The more uneven the surface, the greater the caution needed to set the pins.

Marking lines. All lines on which are to be established the legal corner boundaries are to be marked after this method, viz: Those trees which may intercept your line must have two chops or notches cut on each side of them without any other marks whatever. These are called "*sight-trees*" or "*line-trees*." A sufficient number of other trees standing nearest to your line, on either side of it, are to be *blazed* on two sides diagonally or quartering toward the line, in order to render the line conspicuous and readily to be traced, the blazes

to be opposite each other, coinciding in direction with the line where the trees stand very near it, and to approach nearer each other the further the line passes from the blazed trees. Due care must ever be taken to have the lines so well marked as to be readily followed, and to cut the blazes deep enough to leave recognizable scars as long as the trees stand.

Bushes on or near the line should be bent at right angles therewith, and receive a blow of the axe at about the usual height of blazes from the ground, sufficient to leave them in a bent position, but not to prevent their growth.

On *trial or random lines*, the trees are not to be blazed, unless occasionally from indispensable necessity, and then it must be done so guardedly as to prevent the possibility of confounding the marks of the trial line with the *true*. But bushes and limbs of trees may be lopped, and *stakes set* on the trial or random line, at every *ten* chains, to enable the surveyor on his return to follow and correct the trial lines and establish therefrom the *true* line. To prevent confusion, the temporary stakes set on the trial or random lines must be pulled when the surveyor returns to establish the true line.

Establishing corners. After a true coursing and most exact measurements the establishment of corners is the consummation of the work. If, therefore, the corner be not perpetuated in a permanent and workmanlike manner, the *great* aim of the surveying service will not have been attained. A boundary corner, in a timbered country, is to be a *tree*, if one be found at the precise spot; and if not, a *post* is to be planted thereat; and the position of the corner-post is to be indicated by trees adjacent (called bearing trees), the angular bearings and distances of which, from the corner, are facts to be ascertained and registered in the field-book.

In a region where stone abounds, the corner boundary will be a small monument of stones alongside of a single marked stone, for a township corner—and a *single stone* for all other corners.

In a region where timber is not near, nor stone, the corner will be a *mound of earth*, of prescribed size, varying to suit the case.

The following are the different points for perpetuating corners, viz:

1. For township boundaries, at intervals of every six miles.

2. For section boundaries, at intervals of every mile, or eighty chains.

3. For quarter section boundaries, at intervals of every half mile, or 40 chains.

4. Meander corners are established at all those points where the lines of the public surveys intersect the banks of such rivers, bayous, lakes or islands as are by law directed to be meandered.

Meandering is a term applied to the usual mode of surveying with the compass, particularly as applied to navigable streams. The instructions for this are, in part, as follows:

Both banks of *navigable rivers*, as well as all rivers not embraced in the class denominated as "navigable," the right-angle width of which is *three* chains and upwards, will be meandered by taking the courses and distances of their sinuosities, and the same are to be entered in the field book. At those points where either the township or section lines intersect the banks of a navigable stream or any meanderable line, corners are to be established at the time of running these lines. These are called "meander corners;" and in meandering you are to commence at one of those corners, coursing

the banks or boundary line, and measuring the distance of each course from your commencing corner to the next "meander corner." By the same method you are to meander the opposite bank of the river.

The crossing distance between the *meander corners*, on the same line, and the true bearing and distance between opposite meander corners is to be ascertained by triangulation or direct measurement, in order that the river may be protracted with entire accuracy. The particulars to be given in the field-notes.

You are also to meander, in manner aforesaid, all *lakes* and deep ponds of the area of 25 acres and upwards; also navigable bayous. The precise relative position of islands in a township made fractional by the river in which the same are situated, is to be determined trigonometrically. Sighting to a flag or other fixed object on the island from a special and carefully measured base-line, connected with the surveyed lines, on or near the river bank, you are to form connection between the meander corners on the river to points corresponding thereto, in direct line, on the bank of the

island, and there establish the proper meander corners, and calculate the distance across.

Surveying. The initial point having been established, the lines of the public survey are to be extended therefrom as follows:

Base line. The base line shall be extended east and west from the initial point by the use of solar instruments or transits. The transit should be designated for the alignment of all important lines. The proper corners shall be established at each 40 and 80 chains, and at the intersection of the line with rivers, lakes, or bayous that should be meandered, in accordance with the instructions for the establishment of corners. In order to check errors in measurement, two sets of chainmen, operating independently of each other, must be employed.

Where transits are used, the line will be run by setting off at the point of departure on the principal meridian a tangent to the parallel of latitude, which will be a line falling at right angles to said meridian. The line thus determined will be prolonged by two back and two fore sights at *each* setting of the instrument, turning the horizontal limb 180° in azimuth between the observations. The survey will be con-

tinued on this line for 12 miles, but the corners will be established at the proper points by off-sets northerly from said line, at the end of each half mile.

Principal meridian. The principal meridian shall be extended north and south from the initial point, by the use of solar instruments or transits. Where solar instruments are used, the line will be run in the samé manner as prescribed for running the base line by solar instruments. Where transits are used, observations upon the polar star must be taken within each 12 miles of line run. Two sets of chainmen operating independently of each other must be employed.

Standard parallels. Standard parallels which are also called correction lines, shall be extended east and west from the principal meridian, at intervals of every 24 miles north and south of the base line, in the same manner as prescribed for running the base line.

Guide meridians shall be extended north and south from the base line at intervals of every 24 miles east and west from the principal meridian, in the same manner as prescribed for running the principal meridian.

Exterior of township lines. The east and west boundaries of townships are always to be run from south to north on a true meridian line; and the north and south boundaries are to be run from east to west, or from west to east, on a *random* or trial line, and corrected back to a true line. The distance north or south of the township corner to be closed upon, from the point of intersection of these random lines with the east or west boundary of the township, must be carefully measured and noted. Should it happen, however, that such random line should fall short, or overrun in length, or intersect the east or west boundary more than *three chains'* distance from the township corner thereon, as compared with the corresponding boundary on the south (due allowance being made for convergency) the line, and if necessary the entire exterior boundaries of the township, must be retraced, so as to discover and correct the error. In running random lines, temporary corners are to be set at each 40 and 80 chains, and permanent corners established upon the true line as corrected back, in accordance with instructions, throwing the excess or deficiency on the west

half as prescribed by law. Permanent corners are to be established in accordance with instructions on the east and west township boundaries at the the time they are run. Whenever practicable, the township lines within these tracts of 24 miles miles square must be surveyed in regular order from *south* to *north*, *i. e.*, the exterior boundaries of the township in any one range lying immediately north of the south boundary of such tract of 24 miles square must first be surveyed, and the exteriors of the other three townships in said range extended therefrom in regular order from *south* to *north*, and it is preferable to first survey the entire range of townships in such tract adjoining the east boundary or the west boundary, and the other three ranges in regalar sequence. In cases, however, where the character of the land is such that this rule cannot be complied with, the following will be observed:

In extending the south or north boundaries of a township to the *west*, where the southwest or northwest corners cannot be established in the regular way by running a north and south line, such boundaries will be run west on a true line, allowing for

convergency on the west half mile; and from the township corner established at the end of such boundary, the west boundary will be run *north* or *south* as the case may be. In extending *south* or *north* boundaries of a township to the east, where the *southeast* or *northeast* corner cannot be established in the regular way, the same rule will be observed, except that such boundaries will be run *east on a true line*, and the *east* boundary run *north* or *south*, as the case may be.

INDEX.

CATALOGUE

OF

Practical and Scientific Books

PUBLISHED BY

HENRY CAREY BAIRD & CO.

INDUSTRIAL PUBLISHERS, BOOKSELLERS AND IMPORTERS.

810 Walnut Street, Philadelphia.

☞ Any of the Books comprised in this Catalogue will be sent by mail, free of postage, to any address in the world, at the publication prices.

☞ A Descriptive Catalogue, 84 pages, 8vo., will be sent free and free of postage, to any one in any part of the world, who will furnish his address.

☞ Where not otherwise stated, all of the Books in this Catalogue are bound in muslin.

AMATEUR MECHANICS' WORKSHOP:
A treatise containing plain and concise directions for the manipulation of Wood and Metals, including Casting, Forging, Brazing, Soldering and Carpentry. By the author of the "Lathe and Its Uses." Seventh edition. Illustrated. 8vo. . . . $3.00

ANDRES.—A Practical Treatise on the Fabrication of Volatile and Fat Varnishes, Lacquers, Siccatives and Sealing Waxes.
From the German of ERWIN ANDRES, Manufacturer of Varnishes and Lacquers. With additions on the Manufacture and Application of Varnishes, Stains for Wood, Horn, Ivory, Bone and Leather. From the German of DR. EMIL WINCKLER and LOUIS E. ANDES. The whole translated and edited by WILLIAM T. BRANNT. With 11 illustrations. 12mo. $2.50

ARLOT.—A Complete Guide for Coach Painters:
Translated from the French of M. ARLOT, Coach Painter, for eleven years Foreman of Painting to M. Eherler, Coach Maker, Paris. By A. A. FESQUET, Chemist and Engineer. To which is added an Appendix, containing Information respecting the Materials and the Practice of Coach and Car Painting and Varnishing in the United States and Great Britain. 12mo. . . . $1.25

ARMENGAUD, AMOROUX, AND JOHNSON.—The Practical Draughtsman's Book of Industrial Design, and Machinist's and Engineer's Drawing Companion:

Forming a Complete Course of Mechanical Engineering and Architectural Drawing. From the French of M. Armengaud the elder, Prof. of Design in the Conservatoire of Arts and Industry, Paris, and MM. Armengaud the younger, and Amoroux, Civil Engineers. Rewritten and arranged with additional matter and plates, selections from and examples of the most useful and generally employed mechanism of the day. By WILLIAM JOHNSON, Assoc. Inst. C. E. Illustrated by fifty folio steel plates, and fifty wood-cuts. A new edition, 4to., half morocco $10.00

ARMSTRONG.—The Construction and Management of Steam Boilers:

By R. ARMSTRONG, C. E. With an Appendix by ROBERT MALLET, C. E., F. R. S. Seventh Edition. Illustrated. 1 vol. 12mo. 75

ARROWSMITH.—Paper-Hanger's Companion:

A Treatise in which the Practical Operations of the Trade are Systematically laid down: with Copious Directions Preparatory to Papering; Preventives against the Effect of Damp on Walls; the various Cements and Pastes Adapted to the Several Purposes of the Trade; Observations and Directions for the Panelling and Ornamenting of Rooms, etc. By JAMES ARROWSMITH. 12mo., cloth $1.25

ASHTON.—The Theory and Practice of the Art of Designing Fancy Cotton and Woollen Cloths from Sample:

Giving full instructions for reducing drafts, as well as the methods of spooling and making out harness for cross drafts and finding any required reed; with calculations and tables of yarn. By FREDERIC T. ASHTON, Designer, West Pittsfield, Mass. With fifty-two illustrations. One vol. folio $6.00

ASKINSON.—Perfumes and their Preparation:

A Comprehensive Treatise on Perfumery, containing Complete Directions for Making Handkerchief Perfumes, Smelling-Salts, Sachets, Fumigating Pastils; Preparations for the Care of the Skin, the Mouth, the Hair; Cosmetics, Hair Dyes, and other Toilet Articles. By G.W. ASKINSON. Translated from the German by ISIDOR FURST. Revised by CHARLES RICE. 32 Illustrations. 8vo. $3.00

BAIRD.—Miscellaneous Papers on Economic Questions. By Henry Carey Baird. (*In preparation.*)

BAIRD.—The American Cotton Spinner, and Manager's and Carder's Guide:

A Practical Treatise on Cotton Spinning; giving the Dimensions and Speed of Machinery, Draught and Twist Calculations, etc.; with notices of recent Improvements: together with Rules and Examples for making changes in the sizes and numbers of Roving and Yarn. Compiled from the papers of the late ROBERT H. BAIRD. 12mo. $1.50

BAIRD.—Standard Wages Computing Tables:
An Improvement in all former Methods of Computation, so arranged that wages for days, hours, or fractions of hours, at a specified rate per day or hour, may be ascertained at a glance. By T. SPANGLER BAIRD. Oblong folio $5.00

BAKER.—Long-Span Railway Bridges:
Comprising Investigations of the Comparative Theoretical and Practical Advantages of the various Adopted or Proposed Type Systems of Construction; with numerous Formulæ and Tables. By B. BAKER. 12mo. $1.50

BAKER.—The Mathematical Theory of the Steam-Engine:
With Rules at length, and Examples worked out for the use of Practical Men. By T. BAKER, C. E., with numerous Diagrams. Sixth Edition, Revised by Prof. J. R. YOUNG. 12mo. . 75

BARLOW.—The History and Principles of Weaving, by Hand and by Power:
Reprinted, with Considerable Additions, from "Engineering," with a chapter on Lace-making Machinery, reprinted from the Journal of the "Society of Arts." By ALFRED BARLOW. With several hundred illustrations. 8vo., 443 pages $10.00

BARR.—A Practical Treatise on the Combustion of Coal:
Including descriptions of various mechanical devices for the Economic Generation of Heat by the Combustion of Fuel, whether solid, liquid or gaseous. 8vo. $2.50

BARR.—A Practical Treatise on High Pressure Steam Boilers:
Including Results of Recent Experimental Tests of Boiler Materials, together with a Description of Approved Safety Apparatus, Steam Pumps, Injectors and Economizers in actual use. By WM. M. BARR. 204 Illustrations. 8vo. $3.00

BAUERMAN.—A Treatise on the Metallurgy of Iron:
Containing Outlines of the History of Iron Manufacture, Methods of Assay, and Analysis of Iron Ores, Processes of Manufacture of Iron and Steel, etc., etc. By H. BAUERMAN, F. G. S., Associate of the Royal School of Mines. Fifth Edition, Revised and Enlarged. Illustrated with numerous Wood Engravings from Drawings by J. B. JORDAN. 12mo. $2.00

BAYLES.—House Drainage and Water Service:
In Cities, Villages and Rural Neighborhoods. With Incidental Consideration of Certain Causes Affecting the Healthfulness of Dwellings. By JAMES C. BAYLES, Editor of "The Iron Age" and "The Metal Worker." With numerous illustrations. 8vo. cloth, $3.00

BEANS.—A Treatise on Railway Curves and Location of Railroads:
By E. W. BEANS, C. E. Illustrated. 12mo. Tucks . $1.50

BECKETT.—A Rudimentary Treatise on Clocks, and Watches and Bells:
By Sir EDMUND BECKETT, Bart., LL. D., Q. C. F. R. A. S. With numerous illustrations. Seventh Edition, Revised and Enlarged. 12mo. $2.25

BELL.—Carpentry Made Easy:
Or, The Science and Art of Framing on a New and Improved System. With Specific Instructions for Building Balloon Frames, Barn Frames, Mill Frames, Warehouses, Church Spires, etc. Comprising also a System of Bridge Building, with Bills, Estimates of Cost, and valuable Tables. Illustrated by forty-four plates, comprising nearly 200 figures. By WILLIAM E. BELL, Architect and Practical Builder. 8vo. $5.00

BEMROSE.—Fret-Cutting and Perforated Carving:
With fifty-three practical illustrations. By W. BEMROSE, JR. 1 vol. quarto $2.50

BEMROSE.—Manual of Buhl-work and Marquetry:
With Practical Instructions for Learners, and ninety colored designs. By W. BEMROSE, JR. 1 vol. quarto $3.00

BEMROSE.—Manual of Wood Carving:
With Practical Illustrations for Learners of the Art, and Original and Selected Designs. By WILLIAM BEMROSE, JR. With an Introduction by LLEWELLYN JEWITT, F. S. A., etc. With 128 illustrations, 4to. $2.50

BILLINGS.—Tobacco:
Its History, Variety, Culture, Manufacture, Commerce, and Various Modes of Use. By E. R. BILLINGS. Illustrated by nearly 200 engravings. 8vo. $3.00

BIRD.—The American Practical Dyers' Companion:
Comprising a Description of the Principal Dye-Stuffs and Chemicals used in Dyeing, their Natures and Uses; Mordants, and How Made; with the best American, English, French and German processes for Bleaching and Dyeing Silk, Wool, Cotton, Linen, Flannel, Felt, Dress Goods, Mixed and Hosiery Yarns, Feathers, Grass, Felt, Fur, Wool, and Straw Hats, Jute Yarn, Vegetable Ivory, Mats, Skins, Furs, Leather, etc., etc. By Wood, Aniline, and other Processes, together with Remarks on Finishing Agents, and Instructions in the Finishing of Fabrics, Substitutes for Indigo, Water-Proofing of Materials, Tests and Purification of Water, Manufacture of Aniline and other New Dye Wares, Harmonizing Colors, etc., etc.; embracing in all over 800 Receipts for Colors and Shades, *accompanied by 170 Dyed Samples of Raw Materials and Fabrics.* By F. J. BIRD, Practical Dyer, Author of "The Dyers' Hand-Book." 8vo. $10.00

BLINN.—A Practical Workshop Companion for Tin, Sheet-Iron, and Copper-plate Workers:
Containing Rules for describing various kinds of Patterns used by Tin, Sheet-Iron and Copper-plate Workers; Practical Geometry; Mensuration of Surfaces and Solids; Tables of the Weights of Metals, Lead-pipe, etc.; Tables of Areas and Circumferences of Circles; Japan, Varnishes, Lackers, Cements, Compositions, etc., etc. By LEROY J. BLINN, Master Mechanic. With One Hundred and Seventy Illustrations. 12mo. $2.50

BOOTH.—Marble Worker's Manual:
Containing Practical Information respecting Marbles in general, their Cutting, Working and Polishing; Veneering of Marble; Mosaics; Composition and Use of Artificial Marble, Stuccos, Cements, Receipts, Secrets, etc., etc. Translated from the French by M. L. BOOTH. With an Appendix concerning American Marbles. 12mo., cloth $1.50

BOOTH and MORFIT.—The Encyclopædia of Chemistry, Practical and Theoretical:
Embracing its application to the Arts, Metallurgy, Mineralogy, Geology, Medicine and Pharmacy. By JAMES C. BOOTH, Melter and Refiner in the United States Mint, Professor of Applied Chemistry in the Franklin Institute, etc., assisted by CAMPBELL MORFIT, author of "Chemical Manipulations," etc. Seventh Edition. Complete in one volume, royal 8vo., 978 pages, with numerous wood-cuts and other illustrations $3.50

BRAMWELL.—The Wool Carder's Vade-Mecum:
A Complete Manual of the Art of Carding Textile Fabrics. By W. C. BRAMWELL. Third Edition, revised and enlarged. Illustrated. Pp. 400. 12mo. $2.50

BRANNT.—A Practical Treatise on Animal and Vegetable Fats and Oils:
Comprising both Fixed and Volatile Oils, their Physical and Chemical Properties and Uses, the Manner of Extracting and Refining them, and Practical Rules for Testing them; as well as the Manufacture of Artificial Butter, Lubricants, including Mineral Lubricating Oils, etc., and on Ozokerite. Edited chiefly from the German of DRS. KARL SCHAEDLER, G. W. ASKINSON, and RICHARD BRUNNER, with Additions and Lists of American Patents relating to the Extraction, Rendering, Refining, Decomposing, and Bleaching of Fats and Oils. By WILLIAM T. BRANNT. Illustrated by 244 engravings. 739 pages. 8vo. $7.50

BRANNT.—A Practical Treatise on the Manufacture of Soap and Candles:
Based upon the most Recent Experiences in the Practice and Science; comprising the Chemistry, Raw Materials, Machinery, and Utensils and Various Processes of Manufacture, including a great variety of formulas. Edited chiefly from the German of Dr. C. Deite, A. Engelhardt, Dr. C. Schaedler and others; with additions and lists of American Patents relating to these subjects. By WM. T. BRANNT. Illustrated by 163 engravings. 677 pages. 8vo. . . $7.50

BRANNT.—A Practical Treatise on the Raw Materials and the Distillation and Rectification of Alcohol, and the Preparation of Alcoholic Liquors, Liqueurs, Cordials, Bitters, etc.:
Edited chiefly from the German of Dr. K. Stammer, Dr. F. Elsner, and E. Schubert. By WM. T. BRANNT. Illustrated by thirty-one engravings. 12mo. $2.50

BRANNT—WAHL.—The Techno-Chemical Receipt Book:
Containing several thousand Receipts covering the latest, most important, and most useful discoveries in Chemical Technology, and their Practical Application in the Arts and the Industries. Edited chiefly from the German of Drs. Winckler, Elsner, Heintze, Mierzinski, Jacobsen, Koller, and Heinzerling, with additions by WM. T. BRANNT and WM. H. WAHL, PH. D. Illustrated by 78 engravings. 12mo. 495 pages $2.00

BROWN.—Five Hundred and Seven Mechanical Movements:
Embracing all those which are most important in Dynamics, Hydraulics, Hydrostatics, Pneumatics, Steam-Engines, Mill and other Gearing, Presses, Horology and Miscellaneous Machinery; and including many movements never before published, and several of which have only recently come into use. By HENRY T. BROWN. 12mo. $1.00

BUCKMASTER.—The Elements of Mechanical Physics:
By J. C. BUCKMASTER. Illustrated with numerous engravings. 12mo. $1.50

BULLOCK.—The American Cottage Builder:
A Series of Designs, Plans and Specifications, from $200 to $20,000, for Homes for the People; together with Warming, Ventilation, Drainage, Painting and Landscape Gardening. By JOHN BULLOCK, Architect and Editor of "The Rudiments of Architecture and Building," etc., etc. Illustrated by 75 engravings. 8vo. $3.50

BULLOCK.—The Rudiments of Architecture and Building:
For the use of Architects, Builders, Draughtsmen, Machinists, Engineers and Mechanics. Edited by JOHN BULLOCK, author of "The American Cottage Builder." Illustrated by 250 Engravings. 8vo. $3.50

BURGH.—Practical Rules for the Proportions of Modern Engines and Boilers for Land and Marine Purposes.
By N. P. BURGH, Engineer. 12mo. $1.50

BYLES.—Sophisms of Free Trade and Popular Political Economy Examined.
By a BARRISTER (SIR JOHN BARNARD BYLES, Judge of Common Pleas). From the Ninth English Edition, as published by the Manchester Reciprocity Association. 12mo. $1.25

BOWMAN.—The Structure of the Wool Fibre in its Relation to the Use of Wool for Technical Purposes:
Being the substance, with additions, of Five Lectures, delivered at the request of the Council, to the members of the Bradford Technical College, and the Society of Dyers and Colorists. By F. H. BOWMAN, D. Sc., F. R. S. E., F. L. S. Illustrated by 32 engravings. 8vo. $6.50

BYRNE.—Hand-Book for the Artisan, Mechanic, and Engineer:
Comprising the Grinding and Sharpening of Cutting Tools, Abrasive Processes, Lapidary Work, Gem and Glass Engraving, Varnishing and Lackering, Apparatus, Materials and Processes for Grinding and

Polishing, etc. By OLIVER BYRNE. Illustrated by 185 wood engravings. 8vo. $5.00

BYRNE.—Pocket-Book for Railroad and Civil Engineers: Containing New, Exact and Concise Methods for Laying out Railroad Curves, Switches, Frog Angles and Crossings; the Staking out of work; Levelling; the Calculation of Cuttings; Embankments; Earthwork, etc. By OLIVER BYRNE. 18mo., full bound, pocket-book form $1.75

BYRNE.—The Practical Metal-Worker's Assistant: Comprising Metallurgic Chemistry; the Arts of Working all Metals and Alloys; Forging of Iron and Steel; Hardening and Tempering; Melting and Mixing; Casting and Founding; Works in Sheet Metal; the Processes Dependent on the Ductility of the Metals; Soldering; and the most Improved Processes and Tools employed by Metal-Workers. With the Application of the Art of Electro-Metallurgy to Manufacturing Processes; collected from Original Sources, and from the works of Holtzapffel, Bergeron, Leupold, Plumier, Napier, Scoffern, Clay, Fairbairn and others. By OLIVER BYRNE. A new, revised and improved edition, to which is added an Appendix, containing The Manufacture of Russian Sheet-Iron. By JOHN PERCY, M. D., F. R. S. The Manufacture of Malleable Iron Castings, and Improvements in Bessemer Steel. By A. A. FESQUET, Chemist and Engineer. With over Six Hundred Engravings, Illustrating every Branch of the Subject. 8vo. $5.00

BYRNE.—The Practical Model Calculator: For the Engineer, Mechanic, Manufacturer of Engine Work, Naval Architect, Miner and Millwright. By OLIVER BYRNE. 8vo., nearly 600 pages $4.50

CABINET MAKER'S ALBUM OF FURNITURE: Comprising a Collection of Designs for various Styles of Furniture. Illustrated by Forty-eight Large and Beautifully Engraved Plates. Oblong, 8vo. $2.00

CALLINGHAM.—Sign Writing and Glass Embossing: A Complete Practical Illustrated Manual of the Art. By JAMES CALLINGHAM. 12mo. $1.50

CAMPIN.—A Practical Treatise on Mechanical Engineering: Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Mechanical Manipulation, Manufacture of Steam-Engines, etc. With an Appendix on the Analysis of Iron and Iron Ores. By FRANCIS CAMPIN, C. E. To which are added, Observations on the Construction of Steam Boilers, and Remarks upon Furnaces used for Smoke Prevention; with a Chapter on Explosions. By R. ARMSTRONG, C. E., and JOHN BOURNE. Rules for Calculating the Change Wheels for Screws on a Turning Lathe, and for a Wheel-cutting Machine. By J. LA NICCA. Management of Steel, Including Forging, Hardening, Tempering, Annealing, Shrinking and Expansion; and the Case-hardening of Iron. By G. EDE. 8vo. Illustrated with twenty-nine plates and 100 wood engravings $5.00

CAREY.—A Memoir of Henry C. Carey.
By DR. WM. ELDER. With a portrait. 8vo., cloth . . 75

CAREY.—The Works of Henry C. Carey:
Harmony of Interests: Agricultural, Manufacturing and Commercial. 8vo. $1.50
Manual of Social Science. Condensed from Carey's "Principles of Social Science." By KATE MCKEAN. 1 vol. 12mo. . $2.25
Miscellaneous Works. With a Portrait. 2 vols. 8vo. $10.00
Past, Present and Future. 8vo. $2.50
Principles of Social Science. 3 volumes, 8vo. . . $7.50
The Slave-Trade, Domestic and Foreign; Why it Exists, and How it may be Extinguished (1853). 8vo. . . . $2.00
The Unity of Law: As Exhibited in the Relations of Physical, Social, Mental and Moral Science (1872). 8vo. . . $3.50

CLARK.—Tramways, their Construction and Working:
Embracing a Comprehensive History of the System. With an exhaustive analysis of the various modes of traction, including horse-power, steam, heated water and compressed air; a description of the varieties of Rolling stock, and ample details of cost and working expenses. By D. KINNEAR CLARK. Illustrated by over 200 wood engravings, and thirteen folding plates. 2 vols. 8vo. . $12.50

COLBURN.—The Locomotive Engine:
Including a Description of its Structure, Rules for Estimating its Capabilities, and Practical Observations on its Construction and Management. By ZERAH COLBURN. Illustrated. 12mo. . $1.00

COLLENS.—The Eden of Labor; or, the Christian Utopia.
By T. WHARTON COLLENS, author of "Humanics," "The History of Charity," etc. 12mo. Paper cover, $1.00; Cloth . $1.25

COOLEY.—A Complete Practical Treatise on Perfumery:
Being a Hand-book of Perfumes, Cosmetics and other Toilet Articles. With a Comprehensive Collection of Formulæ. By ARNOLD J. COOLEY. 12mo. $1.50

COOPER.—A Treatise on the use of Belting for the Transmission of Power.
With numerous illustrations of approved and actual methods of arranging Main Driving and Quarter Twist Belts, and of Belt Fastenings. Examples and Rules in great number for exhibiting and calculating the size and driving power of Belts. Plain, Particular and Practical Directions for the Treatment, Care and Management of Belts. Descriptions of many varieties of Beltings, together with chapters on the Transmission of Power by Ropes; by Iron and Wood Frictional Gearing; on the Strength of Belting Leather; and on the Experimental Investigations of Morin, Briggs, and others. By JOHN H. COOPER, M. E. 8vo. $3.50

CRAIK.—The Practical American Millwright and Miller.
By DAVID CRAIK, Millwright. Illustrated by numerous wood engravings and two folding plates. 8vo. $5.00

CREW.—A Practical Treatise on Petroleum:
Comprising its Origin, Geology, Geographical Distribution, History, Chemistry, Mining, Technology, Uses and Transportation. Together with a Description of Gas Wells, the Application of Gas as Fuel, etc. By BENJAMIN J. CREW. With an Appendix on the Product and Exhaustion of the Oil Regions, and the Geology of Natural Gas in Pennsylvania and New York. By CHARLES A. ASHBURNER, M. S., Geologist in Charge Pennsylvania Survey, Philadelphia. Illustrated by 70 engravings. 8vo. 508 pages $5.00

CROSS.—The Cotton Yarn Spinner:
Showing how the Preparation should be arranged for Different Counts of Yarns by a System more uniform than has hitherto been practiced; by having a Standard Schedule from which we make all our Changes. By RICHARD CROSS. 122 pp. 12mo. . 75

CRISTIANI.—A Technical Treatise on Soap and Candles:
With a Glance at the Industry of Fats and Oils. By R. S. CRISTIANI, Chemist. Author of "Perfumery and Kindred Arts." Illustrated by 176 engravings. 581 pages, 8vo. . . . $15.00

CRISTIANI.—Perfumery and Kindred Arts:
A Comprehensive Treatise on Perfumery, containing a History of Perfumes from the remotest ages to the present time. A complete detailed description of the various Materials and Apparatus used in the Perfumer's Art, with thorough Practical Instruction and careful Formulæ, and advice for the fabrication of all known preparations of the day, including Essences, Tinctures, Extracts, Spirits, Waters, Vinegars, Pomades, Powders, Paints, Oils, Emulsions, Cosmetics, Infusions, Pastilles, Tooth Powders and Washes, Cachous, Hair Dyes, Sachets, Essential Oils, Flavoring Extracts, etc.; and full details for making and manipulating Fancy Toilet Soaps, Shaving Creams, etc., by new and improved methods. With an Appendix giving hints and advice for making and fermenting Domestic Wines, Cordials, Liquors, Candies, Jellies, Syrups, Colors, etc., and for Perfuming and Flavoring Segars, Snuff and Tobacco, and Miscellaneous Receipts for various useful Analogous Articles. By R. S. CRISTIANI, Consulting Chemist and Perfumer, Philadelphia. 8vo. . . $10.00

DAVIDSON.—A Practical Manual of House Painting, Graining, Marbling, and Sign-Writing:
Containing full information on the processes of House Painting in Oil and Distemper, the Formation of Letters and Practice of Sign-Writing, the Principles of Decorative Art, a Course of Elementary Drawing for House Painters, Writers, etc., and a Collection of Useful Receipts. With nine colored illustrations of Woods and Marbles, and numerous wood engravings. By ELLIS A. DAVIDSON. 12mo. $3.00

DAVIES.—A Treatise on Earthy and Other Minerals and Mining:
By D. C. DAVIES, F. G. S., Mining Engineer, etc. Illustrated by 76 Engravings. 12mo. $5.00

DAVIES.—A Treatise on Metalliferous Minerals and Mining:
By D. C. DAVIES, F. G. S., Mining Engineer, Examiner of Mines, Quarries and Collieries. Illustrated by 148 engravings of Geological Formations, Mining Operations and Machinery, drawn from the practice of all parts of the world. 2d Edition, 12mo., 450 pages $5.00

DAVIES.—A Treatise on Slate and Slate Quarrying:
Scientific, Practical and Commercial. By D. C. DAVIES, F. G. S., Mining Engineer, etc. With numerous illustrations and folding plates. 12mo. $2.00

DAVIS.—A Treatise on Steam-Boiler Incrustation and Methods for Preventing Corrosion and the Formation of Scale:
By CHARLES T. DAVIS. Illustrated by 65 engravings. 8vo. $1.50

DAVIS.—The Manufacture of Paper:
Being a Description of the various Processes for the Fabrication, Coloring and Finishing of every kind of Paper, Including the Different Raw Materials and the Methods for Determining their Values, the Tools, Machines and Practical Details connected with an intelligent and a profitable prosecution of the art, with special reference to the best American Practice. To which are added a History of Paper, complete Lists of Paper-Making Materials, List of American Machines, Tools and Processes used in treating the Raw Materials, and in Making, Coloring and Finishing Paper. By CHARLES T. DAVIS. Illustrated by 156 engravings. 608 pages, 8vo. $6.00

DAVIS.—The Manufacture of Leather:
Being a description of all of the Processes for the Tanning, Tawing, Currying, Finishing and Dyeing of every kind of Leather; including the various Raw Materials and the Methods for Determining their Values; the Tools, Machines, and all Details of Importance connected with an Intelligent and Profitable Prosecution of the Art, with Special Reference to the Best American Practice. To which are added Complete Lists of all American Patents for Materials, Processes, Tools, and Machines for Tanning, Currying, etc. By CHARLES THOMAS DAVIS. Illustrated by 302 engravings and 12 Samples of Dyed Leathers. One vol., 8vo., 824 pages . . . $10.00

DAWIDOWSKY—BRANNT.—A Practical Treatise on the Raw Materials and Fabrication of Glue, Gelatine, Gelatine Veneers and Foils, Isinglass, Cements, Pastes, Mucilages, etc.:
Based upon Actual Experience. By F. DAWIDOWSKY, Technical Chemist. Translated from the German, with extensive additions, including a description of the most Recent American Processes, by WILLIAM T. BRANNT, Graduate of the Royal Agricultural College of Eldena, Prussia. 35 Engravings. 12mo. . . . $2.50

DE GRAFF.—The Geometrical Stair-Builders' Guide:
Being a Plain Practical System of Hand-Railing, embracing all its necessary Details, and Geometrically Illustrated by twenty-two Steel Engravings; together with the use of the most approved principles of Practical Geometry. By SIMON DE GRAFF, Architect. 4to. $2.50

DE KONINCK—DIETZ.—A Practical Manual of Chemical Analysis and Assaying:

As applied to the Manufacture of Iron from its Ores, and to Cast Iron, Wrought Iron, and Steel, as found in Commerce. By L. L. DE KONINCK, Dr. Sc., and E. DIETZ, Engineer. Edited with Notes, by ROBERT MALLET, F. R. S., F. S. G., M. I. C. E., etc. American Edition, Edited with Notes and an Appendix on Iron Ores, by A. A. FESQUET, Chemist and Engineer. 12mo. . . . $2.50

DUNCAN.—Practical Surveyor's Guide:

Containing the necessary information to make any person of common capacity, a finished land surveyor without the aid of a teacher By ANDREW DUNCAN. Illustrated. 12mo. . . . $1.25

DUPLAIS.—A Treatise on the Manufacture and Distillation of Alcoholic Liquors:

Comprising Accurate and Complete Details in Regard to Alcohol from Wine, Molasses, Beets, Grain, Rice, Potatoes, Sorghum, Asphodel, Fruits, etc.; with the Distillation and Rectification of Brandy. Whiskey, Rum, Gin, Swiss Absinthe, etc., the Preparation of Aromatic Waters, Volatile Oils or Essences, Sugars, Syrups, Aromatic Tinctures, Liqueurs, Cordial Wines, Effervescing Wines, etc., the Ageing of Brandy and the improvement of Spirits, with Copious Directions and Tables for Testing and Reducing Spirituous Liquors, etc., etc. Translated and Edited from the French of MM. DUPLAIS, Ainé et Jeune. By M. MCKENNIE, M. D. To which are added the United States Internal Revenue Regulations for the Assessment and Collection of Taxes on Distilled Spirits. Illustrated by fourteen folding plates and several wood engravings. 743 pp. 8vo. $10 00

DUSSAUCE.—Practical Treatise on the Fabrication of Matches, Gun Cotton, and Fulminating Powder.

By Professor H. DUSSAUCE. 12mo. $3 00

DYER AND COLOR-MAKER'S COMPANION:

Containing upwards of two hundred Receipts for making Colors, on the most approved principles, for all the various styles and fabrics now in existence; with the Scouring Process, and plain Directions for Preparing, Washing-off, and Finishing the Goods. 12mo. $1 25

EDWARDS.—A Catechism of the Marine Steam-Engine,

For the use of Engineers, Firemen, and Mechanics. A Practical Work for Practical Men. By EMORY EDWARDS, Mechanical Engineer. Illustrated by sixty-three Engravings, including examples of the most modern Engines. Third edition, thoroughly revised, with much additional matter. 12 mo. 414 pages . . . $2 00

EDWARDS.—Modern American Locomotive Engines,

Their Design, Construction and Management. By EMORY EDWARDS. Illustrated 12mo. $2.00

EDWARDS.—The American Steam Engineer:

Theoretical and Practical, with examples of the latest and most approved American practice in the design and construction of Steam Engines and Boilers. For the use of engineers, machinists, boiler-makers, and engineering students. By EMORY EDWARDS. Fully illustrated, 419 pages. 12mo. $2.50

EDWARDS.—Modern American Marine Engines, Boilers, and Screw Propellers,

Their Design and Construction. Showing the Present Practice of the most Eminent Engineers and Marine Engine Builders in the United States. Illustrated by 30 large and elaborate plates. 4to. $5.00

EDWARDS.—The Practical Steam Engineer's Guide

In the Design, Construction, and Management of American Stationary, Portable, and Steam Fire-Engines, Steam Pumps, Boilers, Injectors, Governors, Indicators, Pistons and Rings, Safety Valves and Steam Gauges. For the use of Engineers, Firemen, and Steam Users. By EMORY EDWARDS. Illustrated by 119 engravings. 420 pages. 12mo. $2 50

EISSLER.—The Metallurgy of Gold:

A Practical Treatise on the Metallurgical Treatment of Gold-Bearing Ores, including the Processes of Concentration and Chlorination, and the Assaying, Melting, and Refining of Gold. By M. EISSLER. With 132 Illustrations. 12mo. $3.50

EISSLER.—The Metallurgy of Silver:

A Practical Treatise on the Amalgamation, Roasting, and Lixiviation of Silver Ores, including the Assaying, Melting, and Refining of Silver Bullion. By M. EISSLER. 124 Illustrations. 336 pp. 12mo. $4.25

ELDER.—Conversations on the Principal Subjects of Political Economy.

By DR. WILLIAM ELDER. 8vo. $2.50

ELDER.—Questions of the Day,

Economic and Social. By DR. WILLIAM ELDER. 8vo. . $3.00

ERNI.—Mineralogy Simplified.

Easy Methods of Determining and Classifying Minerals, including Ores, by means of the Blowpipe, and by Humid Chemical Analysis, based on Professor von Kobell's Tables for the Determination of Minerals, with an Introduction to Modern Chemistry. By HENRY ERNI, A.M., M.D., Professor of Chemistry. Second Edition, rewritten, enlarged and improved. 12mo. $3.00

FAIRBAIRN.—The Principles of Mechanism and Machinery of Transmission:

Comprising the Principles of Mechanism, Wheels, and Pulleys, Strength and Proportions of Shafts, Coupling of Shafts, and Engaging and Disengaging Gear. By SIR WILLIAM FAIRBAIRN, Bart C. E. Beautifully illustrated by over 150 wood-cuts. In one volume. 12mo $2.50

FLEMING.—Narrow Gauge Railways in America.

A Sketch of their Rise, Progress, and Success. Valuable Statistics as to Grades, Curves, Weight of Rail, Locomotives, Cars, etc. By HOWARD FLEMING. Illustrated, 8vo. $1 00

FORSYTH.—Book of Designs for Headstones, Mural, and other Monuments:

Containing 78 Designs. By JAMES FORSYTH. With an Introduction by CHARLES BOUTELL, M. A. 4 to., cloth . . . $5 00

FRANKEL—HUTTER.—A Practical Treatise on the Manufacture of Starch, Glucose, Starch-Sugar, and Dextrine:
Based on the German of LADISLAUS VON WAGNER, Professor in the Royal Technical High School, Buda-Pest, Hungary, and other authorities. By JULIUS FRANKEL, Graduate of the Polytechnic School of Hanover. Edited by ROBERT HUTTER, Chemist, Practical Manufacturer of Starch-Sugar. Illustrated by 58 engravings, covering every branch of the subject, including examples of the most Recent and Best American Machinery. 8vo., 344 pp. . $3.50

GARDNER.—The Painter's Encyclopædia:
Containing Definitions of all Important Words in the Art of Plain and Artistic Painting, with Details of Practice in Coach, Carriage, Railway Car, House, Sign, and Ornamental Painting, including Graining, Marbling, Staining, Varnishing, Polishing, Lettering, Stenciling, Gilding, Bronzing, etc. By FRANKLIN B. GARDNER. 158 Illustrations. 12mo. 427 pp. $2.00

GARDNER.—Everybody's Paint Book:
A Complete Guide to the Art of Outdoor and Indoor Painting, Designed for the Special Use of those who wish to do their own work, and consisting of Practical Lessons in Plain Painting, Varnishing, Polishing, Staining, Paper Hanging, Kalsomining, etc., as well as Directions for Renovating Furniture, and Hints on Artistic Work for Home Decoration. 38 Illustrations. 12mo., 183 pp. . $1.00

GEE.—The Goldsmith's Handbook:
Containing full instructions for the Alloying and Working of Gold, including the Art of Alloying, Melting, Reducing, Coloring, Collecting, and Refining; the Processes of Manipulation, Recovery of Waste; Chemical and Physical Properties of Gold; with a New System of Mixing its Alloys; Solders, Enamels, and other Useful Rules and Recipes. By GEORGE E. GEE. 12mo. . . $1.75

GEE.—The Silversmith's Handbook:
Containing full instructions for the Alloying and Working of Silver, including the different modes of Refining and Melting the Metal; its Solders; the Preparation of Imitation Alloys; Methods of Manipulation; Prevention of Waste; Instructions for Improving and Finishing the Surface of the Work; together with other Useful Information and Memoranda. By GEORGE E. GEE. Illustrated. 12mo. $1.75

GOTHIC ALBUM FOR CABINET-MAKERS:
Designs for Gothic Furniture. Twenty-three plates. Oblong $2.00

GRANT.—A Handbook on the Teeth of Gears:
Their Curves, Properties, and Practical Construction. By GEORGE B. GRANT. Illustrated. Third Edition, enlarged. 8vo. $1.50

GREENWOOD.—Steel and Iron:
Comprising the Practice and Theory of the Several Methods Pursued in their Manufacture, and of their Treatment in the Rolling-Mills, the Forge, and the Foundry. By WILLIAM HENRY GREENWOOD, F. C. S. With 97 Diagrams, 536 pages. 12mo. $2.00

GREGORY.—Mathematics for Practical Men:
Adapted to the Pursuits of Surveyors, Architects, Mechanics, and Civil Engineers. By OLINTHUS GREGORY. 8vo., plates $3.00

GRIMSHAW.—Saws:
The History, Development, Action, Classification, and Comparison of Saws of all kinds. *With Copious Appendices.* Giving the details of Manufacture, Filing, Setting, Gumming, etc. Care and Use of Saws; Tables of Gauges; Capacities of Saw-Mills; List of Saw-Patents, and other valuable information. By ROBERT GRIMSHAW. Second and greatly enlarged edition, *with Supplement*, and 354 Illustrations. Quarto $5.00

GRISWOLD.—Railroad Engineer's Pocket Companion for the Field:
Comprising Rules for Calculating Deflection Distances and Angles, Tangential Distances and Angles, and all Necessary Tables for Engineers; also the Art of Levelling from Preliminary Survey to the Construction of Railroads, intended Expressly for the Young Engineer, together with Numerous Valuable Rules and Examples. By W. GRISWOLD. 12mo., tucks $1.75

GRUNER.—Studies of Blast Furnace Phenomena:
By M. L. GRUNER, President of the General Council of Mines of France, and lately Professor of Metallurgy at the Ecole des Mines. Translated, with the author's sanction, with an Appendix, by L. D. B. GORDON, F. R. S. E., F. G. S. 8vo. $2.50

Hand-Book of Useful Tables for the Lumberman, Farmer and Mechanic:
Containing Accurate Tables of Logs Reduced to Inch Board Measure, Plank, Scantling and Timber Measure; Wages and Rent, by Week or Month; Capacity of Granaries, Bins and Cisterns; Land Measure, Interest Tables, with Directions for Finding the Interest on any sum at 4, 5, 6, 7 and 8 per cent., and many other Useful Tables. 32 mo., boards. 186 pages 25

HASERICK.—The Secrets of the Art of Dyeing Wool, Cotton, and Linen,
Including Bleaching and Coloring Wool and Cotton Hosiery and Random Yarns. A Treatise based on Economy and Practice. By E. C. HASERICK. *Illustrated by* 323 *Dyed Patterns of the Yarns or Fabrics.* 8vo. $7.50

HATS AND FELTING:
A Practical Treatise on their Manufacture. By a Practical Hatter. Illustrated by Drawings of Machinery, etc. 8vo. . . $1.25

HOFFER.—A Practical Treatise on Caoutchouc and Gutta Percha,
Comprising the Properties of the Raw Materials, and the manner of Mixing and Working them; with the Fabrication of Vulcanized and Hard Rubbers, Caoutchouc and Gutta Percha Compositions, Water proof Substances, Elastic Tissues, the Utilization of Waste, etc., etc. From the German of RAIMUND HOFFER. By W. T. BRANNT. Illustrated 12mo. $2.50

HAUPT—RHAWN.—A Move for Better Roads:
Essays on Road-making and Maintenance and Road Laws, for which Prizes or Honorable Mention were Awarded through the University of Pennsylvania by a Committee of Citizens of Philadelphia, with a Synopsis of other Contributions and a Review by the Secretary, LEWIS M. HAUPT, A. M., C. E.; also an Introduction by WILLIAM H. RHAWN, Chairman of the Committee. 319 pages. 8vo. $2.00

HUGHES.—American Miller and Millwright's Assistant:
By WILLIAM CARTER HUGHES. 12mo. $1.50

HULME.—Worked Examination Questions in Plane Geometrical Drawing:
For the Use of Candidates for the Royal Military Academy, Woolwich; the Royal Military College, Sandhurst; the Indian Civil Engineering College, Cooper's Hill; Indian Public Works and Telegraph Departments; Royal Marine Light Infantry; the Oxford and Cambridge Local Examinations, etc. By F. EDWARD HULME, F. L. S., F. S. A., Art-Master Marlborough College. Illustrated by 300 examples. Small quarto $2.50

JERVIS.—Railroad Property:
A Treatise on the Construction and Management of Railways; designed to afford useful knowledge, in the popular style, to the holders of this class of property; as well as Railway Managers, Officers, and Agents. By JOHN B. JERVIS, late Civil Engineer of the Hudson River Railroad, Croton Aqueduct, etc. 12mo., cloth $2.00

KEENE.—A Hand-Book of Practical Gauging:
For the Use of Beginners, to which is added a Chapter on Distillation, describing the process in operation at the Custom-House for ascertaining the Strength of Wines. By JAMES B. KEENE, of H. M. Customs. 8vo. $1.25

KELLEY.—Speeches, Addresses, and Letters on Industrial and Financial Questions:
By HON. WILLIAM D. KELLEY, M. C. 544 pages, 8vo. . $3.00

KELLOGG.—A New Monetary System:
The only means of Securing the respective Rights of Labor and Property, and of Protecting the Public from Financial Revulsions. By EDWARD KELLOGG. Revised from his work on "Labor and other Capital." With numerous additions from his manuscript. Edited by MARY KELLOGG PUTNAM. Fifth edition. To which is added a Biographical Sketch of the Author. One volume, 12mo.
Paper cover $1.00
Bound in cloth 1.50

KEMLO.—Watch-Repairer's Hand-Book:
Being a Complete Guide to the Young Beginner, in Taking Apart, Putting Together, and Thoroughly Cleaning the English Lever and other Foreign Watches, and all American Watches. By F. KEMLO, Practical Watchmaker. With Illustrations. 12mo. . $1.25

KENTISH.—A Treatise on a Box of Instruments,
And the Slide Rule; with the Theory of Trigonometry and Logarithms, including Practical Geometry, Surveying, Measuring of Timber, Cask and Malt Gauging, Heights, and Distances. By THOMAS KENTISH. In one volume. 12mo. $1.25

KERL.—The Assayer's Manual:
An Abridged Treatise on the Docimastic Examination of Ores, and Furnace and other Artificial Products. By BRUNO KERL, Professor in the Royal School of Mines. Translated from the German by WILLIAM T. BRANNT. Second American edition, edited with Extensive Additions by F. LYNWOOD GARRISON, Member of the American Institute of Mining Engineers, etc. Illustrated by 87 engravings. 8vo. $3.00

KICK.—Flour Manufacture.
A Treatise on Milling Science and Practice. By FREDERICK KICK, Imperial Regierungsrath, Professor of Mechanical Technology in the Imperial German Polytechnic Institute, Prague. Translated from the second enlarged and revised edition with supplement by H. H. P. POWLES, Assoc. Memb. Institution of Civil Engineers. Illustrated with 28 Plates, and 167 Wood-cuts. 367 pages. 8vo. . $10.00

KINGZETT.—The History, Products, and Processes of the Alkali Trade:
Including the most Recent Improvements. By CHARLES THOMAS KINGZETT, Consulting Chemist. With 23 illustrations. 8vo. $2.50

KIRK.—The Founding of Metals:
A Practical Treatise on the Melting of Iron, with a Description of the Founding of Alloys; also, of all the Metals and Mineral Substances used in the Art of Founding. Collected from original sources. By EDWARD KIRK, Practical Foundryman and Chemist. Illustrated. Third edition. 8vo. $2.50

LANDRIN.—A Treatise on Steel:
Comprising its Theory, Metallurgy, Properties, Practical Working, and Use. By M. H. C. LANDRIN, JR., Civil Engineer. Translated from the French, with Notes, by A. A. FESQUET, Chemist and Engineer. With an Appendix on the Bessemer and the Martin Processes for Manufacturing Steel, from the Report of Abram S. Hewitt United States Commissioner to the Universal Exposition, Paris, 1867. 12mo. $3.00

LANGBEIN.—A Complete Treatise on the Electro-Deposition of Metals:
Translated from the German, with Additions, by WM. T. BRANNT. 125 illustrations. 8vo. $4.00

LARDNER.—The Steam-Engine:
For the Use of Beginners. Illustrated. 12mo. 75

LEHNER.—The Manufacture of Ink:
Comprising the Raw Materials, and the Preparation of Writing, Copying and Hektograph Inks, Safety Inks, Ink Extracts and Powders, etc. Translated from the German of SIGMUND LEHNER, with additions by WILLIAM T. BRANNT. Illustrated. 12mo. $2.00

LARKIN.—The Practical Brass and Iron Founder's Guide:
A Concise Treatise on Brass Founding, Moulding, the Metals and their Alloys, etc.; to which are added Recent Improvements in the Manufacture of Iron, Steel by the Bessemer Process, etc., etc. By JAMES LARKIN, late Conductor of the Brass Foundry Department in Reany, Neafie & Co.'s Penn Works, Philadelphia. New edition, revised, with extensive additions. 12mo. $2.50

LEROUX.—A Practical Treatise on the Manufacture of Worsteds and Carded Yarns:
Comprising Practical Mechanics, with Rules and Calculations applied to Spinning; Sorting, Cleaning, and Scouring Wools; the English and French Methods of Combing, Drawing, and Spinning Worsteds, and Manufacturing Carded Yarns. Translated from the French of CHARLES LEROUX, Mechanical Engineer and Superintendent of a Spinning-Mill, by HORATIO PAINE, M. D., and A. A. FESQUET, Chemist and Engineer. Illustrated by twelve large Plates. To which is added an Appendix, containing Extracts from the Reports of the International Jury, and of the Artisans selected by the Committee appointed by the Council of the Society of Arts, London, on Woolen and Worsted Machinery and Fabrics, as exhibited in the Paris Universal Exposition, 1867. 8vo. $5.00

LEFFEL.—The Construction of Mill-Dams:
Comprising also the Building of Race and Reservoir Embankments and Head-Gates, the Measurement of Streams, Gauging of Water Supply, etc. By JAMES LEFFEL & Co. Illustrated by 58 engravings. 8vo. $2.50

LESLIE.—Complete Cookery:
Directions for Cookery in its Various Branches. By MISS LESLIE. Sixtieth thousand. Thoroughly revised, with the addition of New Receipts. 12mo. $1.50

LE VAN.—The Steam Engine and the Indicator:
Their Origin and Progressive Development; including the Most Recent Examples of Steam and Gas Motors, together with the Indicator, its Principles, its Utility, and its Application. By WILLIAM BARNET LE VAN. Illustrated by 205 Engravings, chiefly of Indicator-Cards. 469 pp. 8vo. $4.00

LIEBER.—Assayer's Guide:
Or, Practical Directions to Assayers, Miners, and Smelters, for the Tests and Assays, by Heat and by Wet Processes, for the Ores of all the principal Metals, of Gold and Silver Coins and Alloys, and of Coal, etc. By OSCAR M. LIEBER. 12mo. $1.25

Lockwood's Dictionary of Terms:
Used in the Practice of Mechanical Engineering, embracing those Current in the Drawing Office, Pattern Shop, Foundry, Fitting, Turning, Smith's and Boiler Shops, etc., etc., comprising upwards of Six Thousand Definitions. Edited by a Foreman Pattern Maker, author of "Pattern Making." 417 pp. 12mo. $3.00

LUKIN.—Amongst Machines:
Embracing Descriptions of the various Mechanical Appliances used in the Manufacture of Wood, Metal, and other Substances. 12mo. $1.75

LUKIN.—The Boy Engineers:
What They Did, and How They Did It. With 30 plates. 18mo. $1.75

LUKIN.—The Young Mechanic:
Practical Carpentry. Containing Directions for the Use of all kinds of Tools, and for Construction of Steam-Engines and Mechanical Models, including the Art of Turning in Wood and Metal. By JOHN LUKIN, Author of "The Lathe and Its Uses," etc. Illustrated. 12mo. $1.75

MAIN and BROWN.—Questions on Subjects Connected with the Marine Steam-Engine:
And Examination Papers; with Hints for their Solution. By THOMAS J. MAIN, Professor of Mathematics, Royal Naval College, and THOMAS BROWN, Chief Engineer, R. N. 12mo., cloth . $1.50

MAIN and BROWN.—The Indicator and Dynamometer:
With their Practical Applications to the Steam-Engine. By THOMAS J. MAIN, M. A. F. R., Ass't S. Professor Royal Naval College, Portsmouth, and THOMAS BROWN, Assoc. Inst. C. E., Chief Engineer R. N., attached to the R. N. College. Illustrated. 8vo. . $1.50

MAIN and BROWN.—The Marine Steam-Engine.
By THOMAS J. MAIN, F. R. Ass't S. Mathematical Professor at the Royal Naval College, Portsmouth, and THOMAS BROWN, Assoc. Inst. C. E., Chief Engineer R. N. Attached to the Royal Naval College. With numerous illustrations. 8vo. . . $5.00

MAKINS.—A Manual of Metallurgy:
By GEORGE HOGARTH MAKINS. 100 engravings. Second edition rewritten and much enlarged. 12mo., 592 pages . . $3.00

MARTIN.—Screw-Cutting Tables, for the Use of Mechanical Engineers:
Showing the Proper Arrangement of Wheels for Cutting the Threads of Screws of any Required Pitch; with a Table for Making the Universal Gas-Pipe Thread and Taps. By W. A. MARTIN, Engineer. 8vo. 50

MICHELL.—Mine Drainage:
Being a Complete and Practical Treatise on Direct-Acting Underground Steam Pumping Machinery. With a Description of a large number of the best known Engines, their General Utility and the Special Sphere of their Action, the Mode of their Application, and their Merits compared with other Pumping Machinery. By STEPHEN MICHELL. Illustrated by 137 engravings. 8vo., 277 pages . $6.00

MOLESWORTH.—Pocket-Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers.
By GUILFORD L. MOLESWORTH, Member of the Institution of Civil Engineers, Chief Resident Engineer of the Ceylon Railway. Full-bound in Pocket-book form $1.00

MOORE.—The Universal Assistant and the Complete Mechanic:

Containing over one million Industrial Facts, Calculations, Receipts, Processes, Trades Secrets, Rules, Business Forms, Legal Items, Etc., in every occupation, from the Household to the Manufactory. By R. MOORE. Illustrated by 500 Engravings. 12mo. . . $2.50

MORRIS.—Easy Rules for the Measurement of Earthworks:

By means of the Prismoidal Formula. Illustrated with Numerous Wood-Cuts, Problems, and Examples, and concluded by an Extensive Table for finding the Solidity in cubic yards from Mean Areas. The whole being adapted for convenient use by Engineers, Surveyors, Contractors, and others needing Correct Measurements of Earthwork. By ELWOOD MORRIS, C. E. 8vo. $1.50

MORTON.—The System of Calculating Diameter, Circumference, Area, and Squaring the Circle:

Together with Interest and Miscellaneous Tables, and other information. By JAMES MORTON. Second Edition, enlarged, with the Metric System. 12mo. 50

NAPIER.—Manual of Electro-Metallurgy:

Including the Application of the Art to Manufacturing Processes. By JAMES NAPIER. Fourth American, from the Fourth London edition, revised and enlarged. Illustrated by engravings. 8vo.

NAPIER.—A System of Chemistry Applied to Dyeing.

By JAMES NAPIER, F. C. S. A New and Thoroughly Revised Edition. Completely brought up to the present state of the Science, including the Chemistry of Coal Tar Colors, by A. A. FESQUET, Chemist and Engineer. With an Appendix on Dyeing and Calico Printing, as shown at the Universal Exposition, Paris, 1867. Illustrated. 8vo. 422 pages $3.50

NEVILLE.—Hydraulic Tables, Coefficients, and Formulæ, for finding the Discharge of Water from Orifices, Notches, Weirs, Pipes, and Rivers:

Third Edition, with Additions, consisting of New Formulæ for the Discharge from Tidal and Flood Sluices and Siphons; general information on Rainfall, Catchment-Basins, Drainage, Sewerage, Water Supply for Towns and Mill Power. By JOHN NEVILLE, C. E. M. R. I. A.; Fellow of the Royal Geological Society of Ireland. Thick 12mo. $5.50

NEWBERY.—Gleanings from Ornamental Art of every style:

Drawn from Examples in the British, South Kensington, Indian, Crystal Palace, and other Museums, the Exhibitions of 1851 and 1862, and the best English and Foreign works. In a series of 100 exquisitely drawn Plates, containing many hundred examples. By ROBERT NEWBERY. 4to. $12.50

NICHOLLS.—The Theoretical and Practical Boiler-Maker and Engineer's Reference Book:

Containing a variety of Useful Information for Employers of Labor, Foremen and Working Boiler-Makers, Iron, Copper, and Tinsmiths

Draughtsmen, Engineers, the General Steam-using Public, and for the Use of Science Schools and Classes. By SAMUEL NICHOLLS. Illustrated by sixteen plates, 12mo. $2.50

NICHOLSON.—A Manual of the Art of Bookbinding:
Containing full instructions in the different Branches of Forwarding, Gilding, and Finishing. Also, the Art of Marbling Book-edges and Paper. By JAMES B. NICHOLSON. Illustrated. 12mo., cloth $2.25

NICOLLS.—The Railway Builder:
A Hand-Book for Estimating the Probable Cost of American Railway Construction and Equipment. By WILLIAM J. NICOLLS, Civil Engineer. Illustrated, full bound, pocket-book form . $2.00

NORMANDY.—The Commercial Handbook of Chemical Analysis:
Or Practical Instructions for the Determination of the Intrinsic or Commercial Value of Substances used in Manufactures, in Trades, and in the Arts. By A. NORMANDY. New Edition, Enlarged, and to a great extent rewritten. By HENRY M. NOAD, Ph.D., F.R.S., thick 12mo. $5.00

NORRIS.—A Handbook for Locomotive Engineers and Machinists:
Comprising the Proportions and Calculations for Constructing Locomotives; Manner of Setting Valves; Tables of Squares, Cubes, Areas, etc., etc. By SEPTIMUS NORRIS, M. E. New edition. Illustrated, 12mo. $1.50

NYSTROM.—A New Treatise on Elements of Mechanics:
Establishing Strict Precision in the Meaning of Dynamical Terms: accompanied with an Appendix on Duodenal Arithmetic and Metrology. By JOHN W. NYSTROM, C. E. Illustrated. 8vo. $2.00

NYSTROM.—On Technological Education and the Construction of Ships and Screw Propellers:
For Naval and Marine Engineers. By JOHN W. NYSTROM, late Acting Chief Engineer, U. S. N. Second edition, revised, with additional matter. Illustrated by seven engravings. 12mo. . $1.50

O'NEILL.—A Dictionary of Dyeing and Calico Printing:
Containing a brief account of all the Substances and Processes in use in the Art of Dyeing and Printing Textile Fabrics; with Practical Receipts and Scientific Information. By CHARLES O'NEILL, Analytical Chemist. To which is added an Essay on Coal Tar Colors and their application to Dyeing and Calico Printing. By A. A. FESQUET, Chemist and Engineer. With an appendix on Dyeing and Calico Printing, as shown at the Universal Exposition, Paris, 1867. 8vo., 491 pages $3.50

ORTON.—Underground Treasures:
How and Where to Find Them. A Key for the Ready Determination of all the Useful Minerals within the United States. By JAMES ORTON, A.M., Late Professor of Natural History in Vassar College, N. Y.; Cor. Mem. of the Academy of Natural Sciences, Philadelphia, and of the Lyceum of Natural History, New York; author of the "Andes and the Amazon," etc. A New Edition, with Additions. Illustrated $1.50

OSBORN.—The Prospector's Field Book and Guide:
In the Search for and the Easy Determination of Ores and Other Useful Minerals. By Prof. H. S. OSBORN, LL. D., Author of "The Metallurgy of Iron and Steel;" "A Practical Manual of Minerals, Mines, and Mining." Illustrated by 44 Engravings. 12mo. $1.50

OSBORN.—A Practical Manual of Minerals, Mines and Mining:
Comprising the Physical Properties, Geologic Positions, Local Occurrence and Associations of the Useful Minerals; their Methods of Chemical Analysis and Assay: together with Various Systems of Excavating and Timbering, Brick and Masonry Work, during Driving, Lining, Bracing and other Operations, etc. By Prof. H. S. OSBORN, LL. D., Author of the "Metallurgy of Iron and Steel." Illustrated by 171 engravings from original drawings. 8vo. $4.50

OVERMAN.—The Manufacture of Steel:
Containing the Practice and Principles of Working and Making Steel. A Handbook for Blacksmiths and Workers in Steel and Iron, Wagon Makers, Die Sinkers, Cutlers, and Manufacturers of Files and Hardware, of Steel and Iron, and for Men of Science and Art. By FREDERICK OVERMAN, Mining Engineer, Author of the "Manufacture of Iron," etc. A new, enlarged, and revised Edition. By A. A. FESQUET, Chemist and Engineer. 12mo. . . $1.50

OVERMAN.—The Moulder's and Founder's Pocket Guide:
A Treatise on Moulding and Founding in Green-sand, Dry-sand, Loam, and Cement; the Moulding of Machine Frames, Mill-gear, Hollow-ware, Ornaments, Trinkets, Bells, and Statues; Description of Moulds for Iron, Bronze, Brass, and other Metals; Plaster of Paris, Sulphur, Wax, etc.; the Construction of Melting Furnaces, the Melting and Founding of Metals; the Composition of Alloys and their Nature, etc., etc. By FREDERICK OVERMAN, M. E. A new Edition, to which is added a Supplement on Statuary and Ornamental Moulding, Ordnance, Malleable Iron Castings, etc. By A. A. FESQUET, Chemist and Engineer. Illustrated by 44 engravings. 12mo. . $2.00

PAINTER, GILDER, AND VARNISHER'S COMPANION:
Containing Rules and Regulations in everything relating to the Arts of Painting, Gilding, Varnishing, Glass-Staining, Graining, Marbling, Sign-Writing, Gilding on Glass, and Coach Painting and Varnishing; Tests for the Detection of Adulterations in Oils, Colors, etc.; and a Statement of the Diseases to which Painters are peculiarly liable, with the Simplest and Best Remedies. Sixteenth Edition. Revised, with an Appendix. Containing Colors and Coloring—Theoretical and Practical. Comprising descriptions of a great variety of Additional Pigments, their Qualities and Uses, to which are added, Dryers, and Modes and Operations of Painting, etc. Together with Chevreul's Principles of Harmony and Contrast of Colors. 12mo. Cloth $1.50

PALLETT.—The Miller's, Millwright's, and Engineer's Guide.
By HENRY PALLETT. Illustrated. 12mo. . . . $2.00

PERCY.—The Manufacture of Russian Sheet-Iron.

By JOHN PERCY, M. D., F. R. S., Lecturer on Metallurgy at the Royal School of Mines, and to The Advance Class of Artillery Officers at the Royal Artillery Institution, Woolwich; Author of "Metallurgy." With Illustrations. 8vo., paper . . 50 cts.

PERKINS.—Gas and Ventilation:

Practical Treatise on Gas and Ventilation. With Special Relation to Illuminating, Heating, and Cooking by Gas. Including Scientific Helps to Engineer-students and others. With Illustrated Diagrams. By E. E. PERKINS. 12mo., cloth $1.25

PERKINS AND STOWE.—A New Guide to the Sheet-iron and Boiler Plate Roller:

Containing a Series of Tables showing the Weight of Slabs and Piles to Produce Boiler Plates, and of the Weight of Piles and the Sizes of Bars to produce Sheet-iron; the Thickness of the Bar Gauge in decimals; the Weight per foot, and the Thickness on the Bar or Wire Gauge of the fractional parts of an inch; the Weight per sheet, and the Thickness on the Wire Gauge of Sheet-iron of various dimensions to weigh 112 lbs. per bundle; and the conversion of Short Weight into Long Weight, and Long Weight into Short. Estimated and collected by G. H. PERKINS and J. G. STOWE. $2.50

POWELL—CHANCE—HARRIS.—The Principles of Glass Making.

By HARRY J. POWELL, B. A. Together with Treatises on Crown and Sheet Glass; by HENRY CHANCE, M. A. And Plate Glass, by H. G. HARRIS, Asso. M. Inst. C. E. Illustrated 18mo. . $1.50

PROCTOR.—A Pocket-Book of Useful Tables and Formulæ for Marine Engineers:

By FRANK PROCTOR. Second Edition, Revised and Enlarged. Full-bound pocket-book form $1.50

REGNAULT.—Elements of Chemistry:

By M. V. REGNAULT. Translated from the French by T. FORREST BETTON, M. D., and edited, with Notes, by JAMES C. BOOTH, Melter and Refiner U. S. Mint, and WILLIAM L. FABER, Metallurgist and Mining Engineer. Illustrated by nearly 700 wood-engravings. Comprising nearly 1,500 pages. In two volumes, 8vo., cloth . $7.50

RICHARDS.—Aluminium:

Its History, Occurrence, Properties, Metallurgy and Applications, including its Alloys. By JOSEPH W. RICHARDS, A. C., Chemist and Practical Metallurgist, Member of the Deutsche Chemische Gesellschaft. Illustrated $5.00

RIFFAULT, VERGNAUD, and TOUSSAINT.—A Practical Treatise on the Manufacture of Colors for Painting:

Comprising the Origin, Definition, and Classification of Colors; the Treatment of the Raw Materials; the best Formulæ and the Newest Processes for the Preparation of every description of Pigment, and the Necessary Apparatus and Directions for its Use; Dryers; the Testing, Application, and Qualities of Paints, etc., etc. By MM. RIFFAULT, VERGNAUD, and TOUSSAINT. Revised and Edited by M.

F. MALEPEYRE. Translated from the French, by A. A. FESQUET, Chemist and Engineer. Illustrated by Eighty engravings. In one vol., 8vo., 659 pages $7.50

ROPER.—A Catechism of High-Pressure, or Non-Condensing Steam-Engines:
Including the Modelling, Constructing, and Management of Steam-Engines and Steam Boilers. With valuable illustrations. By STEPHEN ROPER, Engineer. Sixteenth edition, revised and enlarged. 18mo., tucks, gilt edge $2.00

ROPER.—Engineer's Handy-Book:
Containing a full Explanation of the Steam-Engine Indicator, and its Use and Advantages to Engineers and Steam Users. With Formulæ for Estimating the Power of all Classes of Steam-Engines; also, Facts, Figures, Questions, and Tables for Engineers who wish to qualify themselves for the United States Navy, the Revenue Service, the Mercantile Marine, or to take charge of the Better Class of Stationary Steam-Engines. Sixth edition. 16mo., 690 pages, tucks, gilt edge $3.50

ROPER.—Hand-Book of Land and Marine Engines:
Including the Modelling, Construction, Running, and Management of Land and Marine Engines and Boilers. With illustrations. By STEPHEN ROPER, Engineer. Sixth edition. 12mo., tucks, gilt edge. $3.50

ROPER.—Hand-Book of the Locomotive:
Including the Construction of Engines and Boilers, and the Construction, Management, and Running of Locomotives. By STEPHEN ROPER. Eleventh edition. 18mo., tucks, gilt edge . $2.50

ROPER.—Hand-Book of Modern Steam Fire-Engines.
With illustrations. By STEPHEN ROPER, Engineer. Fourth edition, 12mo., tucks, gilt edge $3.50

ROPER.—Questions and Answers for Engineers.
This little book contains all the Questions that Engineers will be asked when undergoing an Examination for the purpose of procuring Licenses, and they are so plain that any Engineer or Fireman of ordinary intelligence may commit them to memory in a short time. By STEPHEN ROPER, Engineer. Third edition $3.00

ROPER.—Use and Abuse of the Steam Boiler.
By STEPHEN ROPER, Engineer. Eighth edition, with illustrations. 18mo., tucks, gilt edge $2.00

ROSE.—The Complete Practical Machinist:
Embracing Lathe Work, Vise Work, Drills and Drilling, Taps and Dies, Hardening and Tempering, the Making and Use of Tools, Tool Grinding, Marking out Work, etc. By JOSHUA ROSE. Illustrated by 356 engravings. Thirteenth edition, thoroughly revised and in great part rewritten. In one vol., 12mo., 439 pages $2.50

ROSE.—Mechanical Drawing Self-Taught:
Comprising Instructions in the Selection and Preparation of Drawing Instruments, Elementary Instruction in Practical Mechanical Draw-

ing, together with Examples in Simple Geometry and Elementary Mechanism, including Screw Threads, Gear Wheels, Mechanical Motions, Engines and Boilers. By JOSHUA ROSE, M. E. Illustrated by 330 engravings. 8vo., 313 pages $4.00

ROSE.—The Slide-Valve Practically Explained:
Embracing simple and complete Practical Demonstrations of the operation of each element in a Slide-valve Movement, and illustrating the effects of Variations in their Proportions by examples carefully selected from the most recent and successful practice. By JOSHUA ROSE, M. E. Illustrated by 35 engravings . $1.00

ROSS.—The Blowpipe in Chemistry, Mineralogy and Geology:
Containing all Known Methods of Anhydrous Analysis, many Working Examples, and Instructions for Making Apparatus. By LIEUT.-COLONEL W. A. ROSS, R. A., F. G. S. With 120 Illustrations. 12mo. $2.00

SHAW.—Civil Architecture:
Being a Complete Theoretical and Practical System of Building, containing the Fundamental Principles of the Art. By EDWARD SHAW, Architect. To which is added a Treatise on Gothic Architecture, etc. By THOMAS W. SILLOWAY and GEORGE M. HARDING, Architects. The whole illustrated by 102 quarto plates finely engraved on copper. Eleventh edition. 4to. $10.00

SHUNK.—A Practical Treatise on Railway Curves and Location, for Young Engineers.
By W. F. SHUNK, C. E. 12mo. Full bound pocket-book form $2.00

SLATER.—The Manual of Colors and Dye Wares.
By J. W. SLATER. 12mo. $3.00

SLOAN.—American Houses:
A variety of Original Designs for Rural Buildings. Illustrated by 26 colored engravings, with descriptive references. By SAMUEL SLOAN, Architect. 8vo. $1.50

SLOAN.—Homestead Architecture:
Containing Forty Designs for Villas, Cottages, and Farm-houses, with Essays on Style, Construction, Landscape Gardening, Furniture, etc., etc. Illustrated by upwards of 200 engravings. By SAMUEL SLOAN, Architect. 8vo. $3.50

SLOANE.—Home Experiments in Science.
By T. O'CONOR SLOANE, E. M., A. M., Ph. D. Illustrated by 91 engravings. 12mo. $1.50

SMEATON.—Builder's Pocket-Companion:
Containing the Elements of Building, Surveying, and Architecture; with Practical Rules and Instructions connected with the subject. By A. C. SMEATON, Civil Engineer, etc. 12mo. . . . $1.50

SMITH.—A Manual of Political Economy.
By E. PESHINE SMITH. A New Edition, to which is added a full Index. 12mo. $1.25

SMITH.—Parks and Pleasure-Grounds:
Or Practical Notes on Country Residences, Villas, Public Parks, and Gardens. By CHARLES H. J. SMITH, Landscape Gardener and Garden Architect, etc., etc. 12mo. $2.00

SMITH.—The Dyer's Instructor:
Comprising Practical Instructions in the Art of Dyeing Silk, Cotton, Wool, and Worsted, and Woolen Goods; containing nearly 800 Receipts. To which is added a Treatise on the Art of Padding; and the Printing of Silk Warps, Skeins, and Handkerchiefs, and the various Mordants and Colors for the different styles of such work. By DAVID SMITH, Pattern Dyer. 12mo. $2.00

SMYTH.—A Rudimentary Treatise on Coal and Coal-Mining.
By WARRINGTON W. SMYTH, M. A., F. R. G., President R. G. S. of Cornwall. Fifth edition, revised and corrected. With numerous illustrations. 12mo. $1.75

SNIVELY.—Tables for Systematic Qualitative Chemical Analysis.
By JOHN H. SNIVELY, Phr. D. 8vo. $1.00

SNIVELY.—The Elements of Systematic Qualitative Chemical Analysis:
A Hand-book for Beginners. By JOHN H. SNIVELY, Phr. D. 16mo. $2.00

STOKES.—The Cabinet-Maker and Upholsterer's Companion:
Comprising the Art of Drawing, as applicable to Cabinet Work; Veneering, Inlaying, and Buhl-Work; the Art of Dyeing and Staining Wood, Ivory, Bone, Tortoise-Shell, etc. Directions for Lackering, Japanning, and Varnishing; to make French Polish, Glues, Cements, and Compositions; with numerous Receipts, useful to workmen generally. By STOKES. Illustrated. A New Edition, with an Appendix upon French Polishing, Staining, Imitating, Varnishing, etc., etc. 12mo $1.25

STRENGTH AND OTHER PROPERTIES OF METALS:
Reports of Experiments on the Strength and other Properties of Metals for Cannon. With a Description of the Machines for Testing Metals, and of the Classification of Cannon in service. By Officers of the Ordnance Department, U. S. Army. By authority of the Secretary of War. Illustrated by 25 large steel plates. Quarto . $10.00

SULLIVAN.—Protection to Native Industry.
By Sir EDWARD SULLIVAN, Baronet, author of "Ten Chapters on Social Reforms." 8vo. $1.50

SULZ.—A Treatise on Beverages:
Or the Complete Practical Bottler. Full instructions for Laboratory Work, with Original Practical Recipes for all kinds of Carbonated Drinks, Mineral Waters, Flavorings, Extracts, Syrups, etc. By CHAS. HERMAN SULZ, Technical Chemist and Practical Bottler. Illustrated by 428 Engravings. 818 pp. 8vo. . . $10.00

SYME.—Outlines of an Industrial Science.
By DAVID SYME. 12mo. $2.00

TABLES SHOWING THE WEIGHT OF ROUND, SQUARE, AND FLAT BAR IRON, STEEL, ETC.,
By Measurement. Cloth 63

TAYLOR.—Statistics of Coal:
Including Mineral Bituminous Substances employed in Arts and Manufactures; with their Geographical, Geological, and Commercial Distribution and Amount of Production and Consumption on the American Continent. With Incidental Statistics of the Iron Manufacture. By R. C. TAYLOR. Second edition, revised by S. S. HALDEMAN. Illustrated by five Maps and many wood engravings. 8vo., cloth $10.00

TEMPLETON.—The Practical Examinator on Steam and the Steam-Engine:
With Instructive References relative thereto, arranged for the Use of Engineers, Students, and others. By WILLIAM TEMPLETON, Engineer. 12mo. $1.25

THAUSING.—The Theory and Practice of the Preparation of Malt and the Fabrication of Beer:
With especial reference to the Vienna Process of Brewing. Elaborated from personal experience by JULIUS E. THAUSING, Professor at the School for Brewers, and at the Agricultural Institute, Mödling, near Vienna. Translated from the German by WILLIAM T. BRANNT. Thoroughly and elaborately edited, with much American matter, and according to the latest and most Scientific Practice, by A. SCHWARZ and DR. A. H. BAUER. Illustrated by 140 Engravings. 8vo., 815 pages $10.00

THOMAS.—The Modern Practice of Photography:
By R. W. THOMAS, F. C. S. 8vo. 75

THOMPSON.—Political Economy. With Especial Reference to the Industrial History of Nations:
By ROBERT E. THOMPSON, M. A., Professor of Social Science in the University of Pennsylvania. 12mo. $1.50

THOMSON.—Freight Charges Calculator:
By ANDREW THOMSON, Freight Agent. 24mo. . . . $1.25

TURNER'S (THE) COMPANION:
Containing Instructions in Concentric, Elliptic, and Eccentric Turning; also various Plates of Chucks, Tools, and Instruments; and Directions for using the Eccentric Cutter, Drill, Vertical Cutter, and Circular Rest; with Patterns and Instructions for working them. 12mo. $1.25

TURNING: Specimens of Fancy Turning Executed on the Hand or Foot-Lathe:
With Geometric, Oval, and Eccentric Chucks, and Elliptical Cutting Frame. By an Amateur. Illustrated by 30 exquisite Photographs. 4to. $3.00

VAILE.—Galvanized-Iron Cornice-Worker's Manual:
Containing Instructions in Laying out the Different Mitres, and Making Patterns for all kinds of Plain and Circular Work. Also, Tables of Weights, Areas and Circumferences of Circles, and other Matter calculated to Benefit the Trade. By CHARLES A. VAILE. Illustrated by twenty-one plates. 4to. $5.00

VILLE.—On Artificial Manures:
Their Chemical Selection and Scientific Application to Agriculture. A series of Lectures given at the Experimental Farm at Vincennes, during 1867 and 1874-75. By M. GEORGES VILLE. Translated and Edited by WILLIAM CROOKES, F. R. S. Illustrated by thirty-one engravings. 8vo., 450 pages $6.00

VILLE.—The School of Chemical Manures:
Or, Elementary Principles in the Use of Fertilizing Agents. From the French of M. GEO. VILLE, by A. A. FESQUET, Chemist and Engineer. With Illustrations. 12mo. $1.25

VOGDES.—The Architect's and Builder's Pocket-Companion and Price-Book:
Consisting of a Short but Comprehensive Epitome of Decimals, Duodecimals, Geometry and Mensuration; with Tables of United States Measures, Sizes, Weights, Strengths, etc., of Iron, Wood, Stone, Brick, Cement and Concretes, Quantities of Materials in given Sizes and Dimensions of Wood, Brick and Stone; and full and complete Bills of Prices for Carpenter's Work and Painting; also, Rules for Computing and Valuing Brick and Brick Work, Stone Work, Painting, Plastering, with a Vocabulary of Technical Terms, etc. By FRANK W. VOGDES, Architect, Indianapolis, Ind. Enlarged, revised, and corrected. In one volume, 368 pages, full-bound, pocket-book form, gilt edges $2.00
Cloth 1.50

VAN CLEVE.—The English and American Mechanic:
Comprising a Collection of Over Three Thousand Receipts, Rules, and Tables, designed for the Use of every Mechanic and Manufacturer. By B. FRANK VAN CLEVE. Illustrated. 500 pp. 12mo. $2.00

WAHNSCHAFFE.—A Guide to the Scientific Examination of Soils:
Comprising Select Methods of Mechanical and Chemical Analysis and Physical Investigation. Translated from the German of Dr. F. WAHNSCHAFFE. With additions by WILLIAM T. BRANNT. Illustrated by 25 engravings. 12mo. 177 pages $1.50

WALL.—Practical Graining:
With Descriptions of Colors Employed and Tools Used. Illustrated by 47 Colored Plates, Representing the Various Woods Used in Interior Finishing. By WILLIAM E. WALL. 8vo. . $2.50

WALTON.—Coal-Mining Described and Illustrated:
By THOMAS H. WALTON, Mining Engineer. Illustrated by 24 large and elaborate Plates, after Actual Workings and Apparatus. $5.00

WARE.—The Sugar Beet.

Including a History of the Beet Sugar Industry in Europe, Varieties of the Sugar Beet, Examination, Soils, Tillage, Seeds and Sowing, Yield and Cost of Cultivation, Harvesting, Transportation, Conservation, Feeding Qualities of the Beet and of the Pulp, etc. By LEWIS S. WARE, C. E., M. E. Illustrated by ninety engravings. 8vo. $4.00

WARN.—The Sheet-Metal Worker's Instructor:

For Zinc, Sheet-Iron, Copper, and Tin-Plate Workers, etc. Containing a selection of Geometrical Problems; also, Practical and Simple Rules for Describing the various Patterns required in the different branches of the above Trades. By REUBEN H. WARN, Practical Tin-Plate Worker. To which is added an Appendix, containing Instructions for Boiler-Making, Mensuration of Surfaces and Solids, Rules for Calculating the Weights of different Figures of Iron and Steel, Tables of the Weights of Iron, Steel, etc. Illustrated by thirty-two Plates and thirty-seven Wood Engravings. 8vo. . $3.00

WARNER.—New Theorems, Tables, and Diagrams, for the Computation of Earth-work:

Designed for the use of Engineers in Preliminary and Final Estimates, of Students in Engineering, and of Contractors and other non-professional Computers. In two parts, with an Appendix. Part I. A Practical Treatise; Part II. A Theoretical Treatise, and the Appendix. Containing Notes to the Rules and Examples of Part I.; Explanations of the Construction of Scales, Tables, and Diagrams, and a Treatise upon Equivalent Square Bases and Equivalent Level Heights. The whole illustrated by numerous original engravings, comprising explanatory cuts for Definitions and Problems, Stereometric Scales and Diagrams, and a series of Lithographic Drawings from Models: Showing all the Combinations of Solid Forms which occur in Railroad Excavations and Embankments. By JOHN WARNER, A. M., Mining and Mechanical Engineer. Illustrated by 14 Plates. A new, revised and improved edition. 8vo. $4.00

WATSON.—A Manual of the Hand-Lathe:

Comprising Concise Directions for Working Metals of all kinds, Ivory, Bone and Precious Woods; Dyeing, Coloring, and French Polishing; Inlaying by Veneers, and various methods practised to produce Elaborate work with Dispatch, and at Small Expense. By EGBERT P. WATSON, Author of "The Modern Practice of American Machinists and Engineers." Illustrated by 78 engravings. $1.50

WATSON.—The Modern Practice of American Machinists and Engineers:

Including the Construction, Application, and Use of Drills, Lathe Tools, Cutters for Boring Cylinders, and Hollow-work generally, with the most Economical Speed for the same; the Results verified by Actual Practice at the Lathe, the Vise, and on the Floor. Together

with Workshop Management, Economy of Manufacture, the Steam Engine, Boilers, Gears, Belting, etc., etc. By EGBERT P. WATSON. Illustrated by eighty-six engravings. 12mo. $2.50

WATSON.—The Theory and Practice of the Art of Weaving by Hand and Power:

With Calculations and Tables for the Use of those connected with the Trade. By JOHN WATSON, Manufacturer and Practical Machine-Maker. Illustrated by large Drawings of the best Power Looms. 8vo. $6.00

WATT.—The Art of Soap Making:

A Practical Hand-book of the Manufacture of Hard and Soft Soaps, Toilet Soaps, etc., including many New Processes, and a Chapter on the Recovery of Glycerine from Waste Leys. By ALEXANDER WATT. Ill. 12mo. $3.00

WEATHERLY.—Treatise on the Art of Boiling Sugar, Crystallizing, Lozenge-making, Comfits, Gum Goods,

And other processes for Confectionery, etc., in which are explained, in an easy and familiar manner, the various Methods of Manufacturing every Description of Raw and Refined Sugar Goods, as sold by Confectioners and others. 12mo. $1.50

WIGHTWICK.—Hints to Young Architects:

Comprising Advice to those who, while yet at school, are destined to the Profession; to such as, having passed their pupilage, are about to travel; and to those who, having completed their education, are about to practise. Together with a Model Specification involving a great variety of instructive and suggestive matter. By GEORGE WIGHTWICK, Architect. A new edition, revised and considerably enlarged; comprising Treatises on the Principles of Construction and Design. By G. HUSKISSON GUILLAUME, Architect. Numerous Illustrations. One vol. 12mo. $2.00

WILL.—Tables of Qualitative Chemical Analysis.

With an Introductory Chapter on the Course of Analysis. By Professor HEINRICH WILL, of Giessen, Germany. Third American, from the eleventh German edition. Edited by CHARLES F. HIMES, Ph. D., Professor of Natural Science, Dickinson College, Carlisle, Pa. 8vo. $1.50

WILLIAMS.—On Heat and Steam:

Embracing New Views of Vaporization, Condensation, and Explosion. By CHARLES WYE WILLIAMS, A. I. C. E. Illustrated 8vo. $3 50

WILSON.—A Treatise on Steam Boilers:

Their Strength, Construction, and Economical Working. By ROBERT WILSON. Illustrated 12mo. $2.50

WILSON.—First Principles of Political Economy:

With Reference to Statesmanship and the Progress of Civilization. By Professor W. D. WILSON, of the Cornell University. A new and revised edition. 12mo. $1.50

WOHLER.—A Hand-Book of Mineral Analysis:

By F. Wöhler, Professor of Chemistry in the University of Göttingen. Edited by Henry B. Nason, Professor of Chemistry in the Renssalaer Polytechnic Institute, Troy, New York. Illustrated. 12mo. $3.00

WORSSAM.—On Mechanical Saws:

From the Transactions of the Society of Engineers, 1869. By S. W. Worssam, Jr. Illustrated by eighteen large plates. 8vo. $2.50

RECENT ADDITIONS.

ANDERSON.—The Prospector's Hand-Book:

A Guide for the Prospector and Traveler in Search of Metal Bearing or other Valuable Minerals. By J. W. Anderson. 52 Illustrations. 12mo. $1.50

BEAUMONT.—Woollen and Worsted Cloth Manufacture:

Being a Practical Treatise for the use of all persons employed in the manipulation of Textile Fabrics. By Robert Beaumont, M. S. A. With over 200 illustrations, including Sketches of Machinery, Designs, Cloths, etc. 391 pp. 12mo. $2.00

BRANNT.—The Metallic Alloys:

A Practical Guide for the Manufacture of all kinds of Alloys, Amalgams and Solders used by Metal Workers, especially by Bell Founders, Bronze Workers, Tinsmiths, Gold and Silver Workers, Dentists, etc., etc., as well as their Chemical and Physical Properties. Edited chiefly from the German of A. Krupp and Andreas Wildberger, with additions by Wm. T. Brannt. Illustrated. 12mo. $3.00

BRANNT.—A Practical Treatise on the Manufacture of Vinegar and Acetates, Cider, and Fruit-Wines:

Preservation of Fruits and Vegetables by Canning and Evaporation; Preparation of Fruit-Butters, Jellies, Marmalades, Catchups, Pickles, Mustards, etc. Edited from various sources. By William T. Brannt. Illustrated by 79 Engravings. 479 pp. 8vo. $5.00

BRANNT.—The Metal Worker's Handy-Book of Receipts and Processes:

Being a Collection of Chemical Formulas and Practical Manipulations for the working of all Metals; including the Decoration and Beautifying of Articles Manufactured therefrom, as well as their Preservation. Edited from various sources. By William T. Brannt. Illustrated. 12mo. $2.50

DEITE.—A Practical Treatise on the Manufacture of Perfumery:
Comprising directions for making all kinds of Perfumes, Sachet Powders, Fumigating Materials, Dentifrices, Cosmetics, etc., with a full account of the Volatile Oils, Balsams, Resins, and other Natural and Artificial Perfume-substances, including the Manufacture of Fruit Ethers, and tests of their purity. By Dr. C. DEITE, assisted by L. BORCHERT, F. EICHBAUM, E. KUGLER, H. TOEFFNER, and other experts. From the German, by WM. T. BRANNT. 28 Engravings. 358 pages. 8vo. $3.00

EDWARDS.—American Marine Engineer, Theoretical and Practical:
With Examples of the latest and most approved American Practice. By EMORY EDWARDS. 85 illustrations. 12mo. . . $2.50

EDWARDS.—600 Examination Questions and Answers:
For Engineers and Firemen (Land and Marine) who desire to obtain a United States Government or State License. Pocket-book form, gilt edge $1.50

POSSELT.—Technology of Textile Design:
Being a Practical Treatise on the Construction and Application of Weaves for all Textile Fabrics, with minute reference to the latest Inventions for Weaving. Containing also an Appendix, showing the Analysis and giving the Calculations necessary for the Manufacture of the various Textile Fabrics. By E. A. POSSELT, Head Master Textile Department, Pennsylvania Museum and School of Industrial Art, Philadelphia, with over 1000 illustrations. 292 pages. 4to. $5.00

POSSELT.—The Jacquard Machine Analysed and Explained:
With an Appendix on the Preparation of Jacquard Cards, and Practical Hints to Learners of Jacquard Designing. By E. A. POSSELT. With 230 illustrations and numerous diagrams. 127 pp. 4to. $3.00

POSSELT.—The Structure of Fibres, Yarns and Fabrics:
Being a Practical Treatise for the Use of all Persons Employed in the Manufacture of Textile Fabrics, containing a Description of the Growth and Manipulation of Cotton, Wool, Worsted, Silk, Flax, Jute, Ramie, China Grass and Hemp, and Dealing with all Manufacturers' Calculations for Every Class of Material, also Giving Minute Details for the Structure of all kinds of Textile Fabrics, and an Appendix of Arithmetic, specially adapted for Textile Purposes. By E. A. POSSELT. Over 400 Illustrations. quarto. . $10.00

RICH.—Artistic Horse-Shoeing:
A Practical and Scientific Treatise, giving Improved Methods of Shoeing, with Special Directions for Shaping Shoes to Cure Different Diseases of the Foot, and for the Correction of Faulty Action in Trotters. By GEORGE E. RICH. 62 Illustrations. 153 pages. 12mo. $1.00

RICHARDSON.—Practical Blacksmithing:

A Collection of Articles Contributed at Different Times by Skilled Workmen to the columns of "The Blacksmith and Wheelwright," and Covering nearly the Whole Range of Blacksmithing, from the Simplest Job of Work to some of the Most Complex Forgings. Compiled and Edited by M. T. RICHARDSON.

Vol. I. 210 Illustrations. 224 pages. 12mo. . . $1.00
Vol. II. 230 Illustrations. 262 pages. 12mo. . . $1.00
Vol. III. 390 Illustrations. 307 pages. 12mo. . . $1.00
Vol. IV. 226 Illustrations. 276 pages. 12mo. . . $1.00

RICHARDSON.—The Practical Horseshoer:

Being a Collection of Articles on Horseshoeing in all its Branches which have appeared from time to time in the columns of "The Blacksmith and Wheelwright," etc. Compiled and edited by M. T. RICHARDSON. 174 illustrations. $1.00

ROPER.—Instructions and Suggestions for Engineers and Firemen:

By STEPHEN ROPER, Engineer. 18mo. Morocco . $2.00

ROPER.—The Steam Boiler: Its Care and Management:

By STEPHEN ROPER, Engineer. 12mo., tuck, gilt edges. $2.00

ROPER.—The Young Engineer's Own Book:

Containing an Explanation of the Principle and Theories on which the Steam Engine as a Prime Mover is Based. By STEPHEN ROPER, Engineer. 160 illustrations, 363 pages. 18mo., tuck . $3.00

ROSE.—Modern Steam-Engines:

An Elementary Treatise upon the Steam-Engine, written in Plain language; for Use in the Workshop as well as in the Drawing Office. Giving Full Explanations of the Construction of Modern Steam-Engines: Including Diagrams showing their Actual operation. Together with Complete but Simple Explanations of the operations of Various Kinds of Valves, Valve Motions, and Link Motions, etc., thereby Enabling the Ordinary Engineer to clearly Understand the Principles Involved in their Construction and Use, and to Plot out their Movements upon the Drawing Board. By JOSHUA ROSE, M. E. Illustrated by 422 engravings. 4to., 320 pages . . $6.00

ROSE.—Steam Boilers:

A Practical Treatise on Boiler Construction and Examination, for the Use of Practical Boiler Makers, Boiler Users, and Inspectors; and embracing in plain figures all the calculations necessary in Designing or Classifying Steam Boilers. By JOSHUA ROSE, M. E. Illustrated by 73 engravings. 250 pages. 8vo. $2.50

SCHRIBER.—The Complete Carriage and Wagon Painter:

A Concise Compendium of the Art of Painting Carriages, Wagons, and Sleighs, embracing Full Directions in all the Various Branches, including Lettering, Scrolling, Ornamenting, Striping, Varnishing, and Coloring, with numerous Recipes for Mixing Colors. 73 Illustrations. 177 pp. 12mo. $1.00